A66 Northern Trans-Pennine Project
TR010062

3.2 Environmental Statement Chapter 9 Geology and Soils

APFP Regulations 5(2)(a)

Planning Act 2008

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3.2 ENVIRONMENTAL STATEMENT CHAPTER 9 GEOLOGY AND SOILS

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FIGURES (VOLUME 2)

TECHNICAL APPENDICES (VOLUME 3)

9 Geology and Soils

9.1 Introduction

9.1.1 This chapter assesses the likely significant geology and soils effects of the construction and operation of the Project, following the methodology set out in the *Design Manual for Roads and Bridges (DMRB) LA 109 Geology and Soils (DMRB LA 109)* (Highways England (now National Highways), 2019)[1] and the Environment Agency's *Land Contamination: Risk Management* (LCRM) guidance (Environment Agency, 2020)[2] and any other relevant guidance. It details the methodology followed, summarises the legislation and policy framework relevant to the geology and soils assessment and describes the existing environment in the area surrounding the Project. It then considers the design, mitigation and residual effects of the Project, including taking account of relevant characteristics of the future baseline environment. Any key assumptions and limitations applicable to the assessment are also identified.

9.1.2 Any geology and soils effects predicted to be significant are identified in section 9.10. Assessment of likely significant effects of this chapter. Effects identified in the course of the assessment but not predicted to be significant are presented in ES Appendix 9.1: Non-Significant Effects (Application Document 3.4).

9.1.3 The geology and soils assessment is supported by a number of Figures (Environmental Statement Volume 2 (Application Document 3.3)) and Appendices (Environmental Statement Volume 3 (Application Document 3.4)) as listed on the contents page.

9.1.4 This Environmental Impact Assessment (EIA) and preparation of this chapter has been undertaken by competent experts with the relevant and appropriate experience in their respective topics. The lead author of this chapter has the following relevant credentials:

- MSc Applied Environmental Geology; BSc (Hons) Geology
- Chartered Scientist, Member of Institution of Environmental Sciences
- 24 years of experience in professional practice
- Qualified Person, Definition of Waste Contaminated Land: Application in Real Environments (CL:AIRE).

9.2 Key assessment parameters

9.2.1 The following key assessment parameters have been used in order to enable consistency in the assessment and to ensure that a reasonable worst case has been assessed.

[1] Highways England (now National Highways) (2019) Design Manual for Roads and Bridges (DMRB) LA 109 - Geology and soils. Volume 11, Section 3, Part 11 & Part 6]
[2] Environment Agency (2020) Environment Agency's Land Contamination: Risk Management, [accessed 20 January 2022]

Table 9-1: Key assessment parameters

Key Assessment Parameters
• Proximity of contamination sources and receptors to the Project have been identified in Zones up to 250m from the centre line of the proposed works shown Figure 9.5: Potential Contamination Sources; • The potential contaminated land sites have been assigned a predicted risk rating from Class 1 (low risk) to Class 3 (high risk). The risk ratings have been applied based on the Department of Environment Industrial profiles[3] and professional judgement. The DOE Industrial profiles provide information on the processes, materials and waste associated with individual industries with regard to land contamination and remain key guidance in the industry • Where limited site information is available professional judgement has been used and a worst case, high risk rating has been applied; • Foot and mouth sites have been provided at postcode point data level. The size of the sites is unknown. Professional judgement has been applied where sites are located at the edge of the study area. The number of animals, receptor sensitivity and construction activities have been considered in the assessment. • Construction activity impact score - where both a cutting and embankment, for example, is within a similar distance to a potential contaminated land site, a higher impact score is adopted i.e., cutting would be the worst-case scenario • Where potential contaminated sites and / or highly sensitive receptors have been identified at the boundary of the 250m study area, sites have been considered and included in the assessment, where relevant; • A soils and agricultural land survey was carried out within the Order limits and covered approximately 754ha of which approximately 379ha will be permanent land take (urban land, mainly existing roads).

9.3 Legislation and policy framework

Legislation

9.3.1 The following key legislation is applicable to the assessment:

Environmental Protection Act (EPA) 1990 (as amended by the Environmental Act 1995) Part 2A Contaminated Land Statutory Guidance

9.3.2 The UK Legislation on contaminated land is principally contained in Part 2A of the Environmental Protection Act, 1990.

9.3.3 The legislation endorses the principle of a ‘suitable for use’ approach to contaminated land, where remedial action is only required if there are unacceptable risks to health or the environment, taking into account the use of the land and its environmental setting.

[3] CI:AIRE (1995) Department of Environment (DoE) Industry Profiles]

9.3.4 The statutory guidance describes a risk assessment methodology in terms of "significant pollutants" and "significant pollutant linkages" within a source-pathway-receptor conceptual model of the site. The model comprises:

- The principal contaminants associated within the site (the sources);
- The principal receptor(s) at risk from the identified hazards; and
- The existence, or absence, of plausible pathways which may exist between the identified hazards and receptors.

9.3.5 For land to be determined to be statutorily 'contaminated' and require remediation or a for a change to a more sensitive use to trigger this, all three elements (source-pathway-receptor) of a linkage must be present. A possibility of significant harm to one or all of a number of identified receptors must be demonstrated.

The Water Act 2003

9.3.6 Section 86 of the Act makes amendments to Part 2A of the Environmental Protection Act 1990 ("the 1990 Act") in relation to the definition of contaminated land. The definition of "contaminated land" in section 78A of the 1990 Act is amended so that, in relation to the pollution of controlled waters, for land to be determined as contaminated land, it must cause significant pollution or the significant possibility of such pollution of controlled waters.

Contaminated Land (England) (Amendment) Regulations 2012 ("Contaminated Land Regulations")

9.3.7 The Contaminated Land Regulations clarify the process for the designation of contaminated land and promote a risk-based approach to identifying contaminated land. The Contaminated Land Regulations set out provisions for identification of special sites, the attribution of remediation responsibilities to appropriate persons where possible, remediation notices, appeals against such notices and public registers.

9.3.8 The Regulations also reflect the amendments to the controlled water classifications. Water classed using section 82 of the Water Resources Act 1991 is afforded protection alongside waters that are now being classified as 'protected areas' under Annex IV of the Water Framework Directive.

9.3.9 Other key legislation applicable to the assessment are:

- Wildlife and Countryside Act 1981 (as amended)
- National Parks and Access to the Countryside Act 1949 (as amended)
- Part IIA of the Environmental Protection Act (EPA) 1990 (the "contaminated land" regime) (as amended)
- Water Resources Act 1991 (WRA 1991) (as amended)
- Town and Country Planning Act 1990 (as amended)
- Building Act 1984 and the Building Regulations 2010 (as amended)
- Water Act 2003 (as amended)

- Environmental Permitting (England and Wales) (Amendment) Regulations 2016/1154
- Highways Act 1980 Section 105A
- Water Framework Directive (2000/60/EC) (as amended)
- The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017
- The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017.

National level policy

National Policy Statement for National Networks

9.3.10 The primary basis for the Secretary of State (SoS) deciding whether to grant a Development Consent Order (DCO) for the Project is the *National Policy Statement for National Networks (NPSNN)* (Department of Transport, 2014)[4]

9.3.11 Table 9-2: Relevant *NPSNN* policies identifies the policies relevant to the Geology and Soils assessment and a reference to where in this Environmental Statement (ES) information is provided to address each policy.

Table 9-2: Relevant *NPSNN* policies

NPSNN paragraph reference	Requirement	Applicant response	Where addressed?
5.168	Where possible, developments should be on previously developed (brownfield) sites, ensuring consideration is given to the risk posed by land contamination and how it will be addressed.	The Project is an upgrade to an existing road and therefore where online widening is feasible it utilises the previously developed land. Where this has not been feasible; routes have been selected to avoid likely significant impacts and mitigation measures adopted to minimise negative impacts on the environment. Throughout Options Selection and Options Identification, a core principle adopted for the Appleby to Brough scheme was the aim to develop a route that could be constructed outside of the North Pennines AONB, UNESCO Global Geopark in accordance with the NPSNN paragraphs 5.151, 5.152, 5.154, and 5.155. Following a design review from both an environmental and engineering perspective at the beginning of the Preliminary Design stage, it was determined that the Appleby to Brough scheme could not be constructed without land take within the North Pennines AONB/ UNESCO Global Geopark.	Section 9.8 Potential impacts Chapter 3: Assessment of Alternatives Section 9.9: Essential

[4] Department of Transport (2014) National Policy Statement for National Networks

NPSNN paragraph reference	Requirement	Applicant response	Where addressed?
		Potential impacts from possible contamination sources, pathways and key receptors have been identified from a variety of information sources within the study area. The location of potential contamination sources has been identified relative to the Order Limits. The potential impact to geodiversity, soils, human health, surface water and groundwater quality from identified potential contamination sources has been established. Design, mitigation and enhancement measures have been assessed to address any impacts identified arising from potential contamination sources and ensuring they are appropriately mitigated.	mitigation and enhancement measures
5.168	The economic and other benefits of the best and most versatile agricultural land (BMV) should be taken into account. Where significant development on agricultural land is necessary, the Project should seek to use areas of poorer quality land in preference to those of a higher quality. The Project should also identify any effects, and seek to minimise impacts, on soil quality, taking into account any mitigation measures proposed.	Natural England Strategic ALC (Agricultural Land Classification) Maps and Ministry of Agriculture, Fisheries and Food (MAFF) Provisional ALC Maps have been consulted for each of the study areas. These maps indicate the baseline likelihood of BMV agricultural land, i.e., better quality land (Grade 1 to Grade 3a) and lower quality land (Grade 3b to Grade 5). A soil survey has been completed along the route to compliment desk study information and confirm proven soil conditions, quality and ALC Grades and location. The information has been used to assess impacts to permanent and temporary land take and identify measures to avoid and/ or minimise adverse impacts. For areas of temporary development, the ALC Grade as determined from the soil survey will be used to inform the restoration criteria; BMV is to be returned to the same quality as far as reasonably practicable to minimise BMV losses and limit permanent impacts. An assessment of likely significant soil and geology effects that could arise as a result of the Project has been undertaken and are detailed later in this chapter.	Section 9.9: Essential mitigation and enhancement measures Section 9.10 Assessment of likely significant effects

NPSNN paragraph reference	Requirement	Applicant response	Where addressed?
		Where potential impacts have been identified on soil quality during construction and operation phases, design, mitigation and enhancement measures have been established to minimise these impacts. Mitigation and enhancement measures are outlined later in this chapter.	
5.22	The ES should clearly set out any likely significant effects on internationally, nationally and locally designated sites of geological conservation importance.	Any designated sites of geological conservation importance have been identified at an international, national, and local level through the review of desk-based information sources. The Project is partly located in the North Pennines Area of Outstanding Natural Beauty (AONB) and UNESCO Global Geopark. The likely effects of the Project on the Geopark area have been set out further in this chapter. The impacts to the AONB are considered in ES Chapter 10: Landscape and Visual.	Chapter 3: Assessment of Alternatives Section 9.8 Potential impacts
5.23	It should be demonstrated how the Project has taken advantage of opportunities to conserve and enhance geological conservation interests.	Where potential impacts have been identified from desk-based information, enhancement and conservation measures have also been established to ensure any potential impact is appropriately mitigated. The design of the Project has taken into consideration the UNESCO Global Geopark and where possible the route and associated works have been moved to avoid significant impacts to the designated site. Where this has not been possible this design aims to minimise work on the very edge of the Geopark. Earthworks, such as cuttings and borrow pits, can have the potential to offer an opportunity for the enhancement of geodiversity, where excavations create temporary or permanent exposures of scientific interest.	Chapter 3: Assessment of Alternatives Section 9.9 Essential mitigation and enhancement measures
5.25	A s a general principle, and subject to the specific policies below, development should avoid significant harm to biodiversity and geological conservation interests, including through	Where potential impacts have been identified from desk-based information, enhancement and conservation measures have also been established to ensure any potential impact is appropriately mitigated. The design of the Project has taken into consideration the UNESCO Global Geopark and where possible the route and associated works have been moved to	Chapter 3: Assessment of Alternatives Section 9.9 Essential mitigation and

NPSNN paragraph reference	Requirement	Applicant response	Where addressed?
	mitigation and consideration of reasonable alternatives. The applicant may also wish to make use of biodiversity offsetting75 in devising compensation proposals to counteract any impacts on biodiversity which cannot be avoided or mitigated. Where significant harm cannot be avoided or mitigated, as a last resort, appropriate compensation measures should be sought.	avoid likely significant impacts to the designated site. Where this has not been possible the design aims to minimise work to the very edge of the Geopark.	enhancement measures

National Planning Policy Framework

9.3.12 The *National Planning Policy Framework (NPPF)* (Ministry of Housing Communities & Local Government, 2021)[5], originally published in March 2012 and most recently updated in July 2021, sets out the government's planning policies for England and provides a framework within which locally prepared plans can be produced and applications for planning permission can be assessed. The NPPF states the NSIPs should be *"determined in accordance with the decision-making framework in the Planning Act 2008 (as amended) and relevant national policy statements for major infrastructure, as well as any other matters that are relevant (which may include the National Planning Policy Framework)." The NPPF also sets out guidance on Conserving and enhancing the natural environment* (Ministry of Housing, Communities & Local Government, 2021)[6]

Regional and local level policy

9.3.13 Other regional and local level policies have been considered as part of the geology and soils assessment where these have informed the identification of receptors and resources and their sensitivity; the

[5] Ministry of Housing Communities & Local Government (2021) National Planning Policy Framework (2021
[6] Ministry of Housing, Communities & Local Government (2021) National Planning Policy Framework, Paragraphs 174 to 188 Conserving and enhancing the natural environment]

assessment methodology; the potential for likely significant environmental effects; and required mitigation. These policies include:

- *Eden Core Strategy Development Plan*, March 2010 (Eden District Council, 2010)[7], Policy CS16
- *County Durham Development Plan* (adopted 2020) (Durham County Council, 2020)[8], Policies 38, 41, 42 and 43
- *Richmondshire Local Plan 2012-2028 Core Strategy* (Richmondshire District Council, 2014)[9] Policy CP12
- North Pennines Area of Outstanding Natural Beauty (AONB) *Geodiversity Audit and Action Plan, 2018-2022* (North Pennines Area of Outstanding Natural Beauty and UNESCO Global Geopark, 2018)[10.]
- *County Durham Geodiversity Audit 2004* (Durham County Council, 2004)[11]
- *Cumbria Local Geodiversity Action Plan* January 2009 (Cumbria RIGS Group, 2009)[12]
- North Yorkshire County Council (2017) *North Yorkshire Minerals and Waste Plan* (North Yorkshire County Council, 2017)[13]
- Eden District Council & Partners. *Development of Potentially Contaminated Land and Sensitive End uses. An essential guide for developers* (Eden District Council & Partners, 2011)[14.]

Table 9-3: Regional and local level policies

Policy document	Policy wording	Applicant response	Where addressed?
Eden District Council (2010) *Core Strategy Development Plan Document*	The document states 'development should accord with the principles of protection and enhancement of the District including geodiversity and especially those areas designated as being of international, national and local importance'.	The policy document applies to schemes M6 Junction 40 to Kemplay Bank, Penrith to Temple Sowerby, Temple Sowerby to Appleby and Appleby to Brough. Any designated sites of geological conservation importance have been identified at an international, national, and local level through the review of desk-based information sources. The Project is located on the southern edge of the North Pennines Area of	Chapter 3: Assessment of Alternatives Section 9.9 Essential mitigation and enhancement measures

[7] Eden District Council (2010) Core Strategy Development Plan Document
[8] Durham County Council (2020) County Durham Plan. Adopted 2020
[9] Richmondshire District Council (2014) Richmondshire Local Plan 2012-2018 Core Strategy. Adopted 9 December 2014
[10] North Pennines Area of Outstanding Natural Beauty and UNESCO Global Geopark (2018) Geodiversity Action Plan 2018-2022
[11] Durham County Council (2004) Durham Geodiversity Audit
[12] Cumbria RIGS Group (2009) A Local Geodiversity Action Plan for Cumbria. Prepared by Cumbria RIGS Group
[13] North Yorkshire County Council (2017) North Yorkshire Minerals and Waste Plan (Minerals and Waste Development Scheme, Seventh Review 2017
[14] Eden District Council & Partners (2011). Development of Potentially Contaminated Land and sensitive End uses. An essential guide for developers

Policy document	Policy wording	Applicant response	Where addressed?
		Outstanding Natural Beauty and UNESCO Global Geopark. The design of the Project has taken into consideration the UNESCO Global Geopark and where possible the route and associated works have been moved to avoid likely significant impacts to the designated site. Where this has not been possible the design aims to minimise work to the very edge of the Geopark and enhancement opportunities have been identified where possible. The impacts of the Project within the UNESCO Global Geopark area have been assessed in the detailed risk assessment and appraised further on in this chapter. The impacts to the AONB are considered in Chapter 10: Landscape and Visual.	
Durham County Council (2020) *County Durham Plan*	Durham County Council's existing development plan comprises several local plans that are statutory planning documents that shape the development policy for a particular area of land use, development and protection, which include a Mineral Local Plan adopted in 2000. Policy 41 states 'proposals for new development will be expected to protect geological features and have regard to Geodiversity Action Plans, the Durham Geodiversity Audit and where appropriate promote public access, appreciation and interpretation of geodiversity. Development proposals where the primary	The policy document applies to scheme Bowes Bypass Cross Lanes to Rokeby and Stephen Bank to Carkin Moor. Within the Durham area, the Project is located on the southern edge of the North Pennines Area of Outstanding Natural Beauty and UNESCO Global Geopark. The design of the Project has taken into consideration the UNESCO Global Geopark and where possible the route and associated works have been moved to avoid likely significant impacts to the designated site. Where this has not been possible the design aims to minimise work to the very edge of the Geopark and enhancement opportunities have been identified where possible. The impacts of the Project within the UNESCO Global Geopark area have been assessed in the detailed risk assessment and appraised further on in this chapter. The impacts to the AONB are considered in Chapter 10: Landscape and Visual.	Section 9.10 Assessment of likely significant effects Section 9.7 Baseline conditions

Policy document	Policy wording	Applicant response	Where addressed?
	objective is to conserve or enhance biodiversity or geodiversity will be permitted, where they accord with other relevant policies in the Plan'	County Durham has seen extensive opencast coal mining activity over the past 50 years.	
North Pennines Area of Outstanding Natural Beauty (AONB) and UNESCO Global Geopark (2018) *Geodiversity Action Plan 2018-2022*	The AONB Partnership worked with the British Geological Survey to produce a Geodiversity Audit and Action Plan for the North Pennines AONB and UNESCO Global Geopark. The plan focuses on working to make the most of the area's geodiversity during the period 2018 to 2022. The production and review of the plan is the fulfilment of an action in the statutory North Pennines AONB Management Plan.	The policy document applies to schemes Appleby to Brough and Bowes Bypass. the Project is located on the southern edge of the North Pennines Area of Outstanding Natural Beauty and UNESCO Global Geopark. The design of the Project has taken into consideration the UNESCO Global Geopark and where possible the route and associated works have been moved to avoid likely significant impacts to the designated site. Where this has not been possible the design aims to minimise work to the very edge of the Geopark and enhancement opportunities have been identified where possible. The impacts of the Project within the UNESCO Global Geopark area have been assessed in the detailed risk assessment and appraised further on in this chapter. The impacts to the AONB are considered in Chapter 10: Landscape and Visual.	Section 9.8 Potential impacts
Durham County Council (2004) *Durham Geodiversity Audit*	The audit details policies "The County Council will promote the creation of new geological sites at scientifically important horizons during the construction of major developments such as road building and improvements". It also recommends opportunities for enhancement 'common practice in road construction to cover rock exposures in	The policy document applies to schemes Bowes Bypass Cross Lanes to Rokeby and Stephen Bank to Carkin Moor. Policy document applies to scheme Bowes Bypass Cross Lanes to Rokeby and Stephen Bank to Carkin Moor. Within the Durham area, the Project is located on the southern edge of the North Pennines Area of Outstanding Natural Beauty and UNESCO Global Geopark. The design of the Project has taken into consideration the UNESCO	Section 9.7 Baseline conditions

Policy document	Policy wording	Applicant response	Where addressed?
	excavations, particularly cuttings, thus permanently obliterating potentially important geological exposures. With careful and imaginative planning such exposures could be retained as interesting and instructive landscape features with considerable educational value'.	Global Geopark and where possible the route and associated works have been moved to avoid likely significant impacts to the designated site. Where this has not been possible the design aims to minimise work to the very edge of the Geopark and enhancement opportunities have been identified where possible. The impacts of the Project within the UNESCO Global Geopark area have been assessed in the detailed risk assessment and appraised further on in this chapter. The impacts to the AONB are considered in Chapter 10: Landscape and Visual.	
Cumbria RIGS Group (2009) *A Local Geodiversity Action Plan for Cumbria*	The Cumbria Local Geodiversity Action Plan sets out a strategy with the aim of conserving, protecting and enhancing the geological and geomorphological heritage of Cumbria for the future. It is envisaged the plan will enable those parties with a common interest in, or obligation to, the geodiversity of the region to work collectively towards these aims.	Policy document applies to schemes M6 Junction 40 to Kemplay Bank, Penrith to Temple Sowerby, Temple Sowerby to Appleby and Appleby to Brough. The Appleby to Brough scheme is located on the southern edge of the North Pennines Area of Outstanding Natural Beauty and UNESCO Global Geopark. The design of the Project has taken into consideration the UNESCO Global Geopark and where possible the route and associated works have been moved to avoid likely significant impacts to the designated site. Where this has not been possible the design aims to minimise work to the very edge of the Geopark and enhancement opportunities have been identified where possible. The impacts of the Project within the UNESCO Global Geopark area have been assessed in the detailed risk assessment and appraised further on in this chapter. The impacts to the AONB are considered in Chapter 10: Landscape and Visual. No geodiversity sites have been identified within the remaining part	Section 9.10 Assessment of likely significant effects Section 9.7 Baseline conditions

Policy document	Policy wording	Applicant response	Where addressed?
		of the scheme located within Cumbria.	
Richmondshire Local Plan 2012-2028 Core Strategy	Within the Core Strategy, Core Policy CP4: Supporting Sites for Development indicates the development should be consistent with the requirements of core policies, and should not lead to the loss of, or adverse impact on, or cause deterioration or important nature conservation, geodiversity sites.	Policy document applies to schemes Stephen Bank to Carkin Moor and A1(M) Junction 53 Scotch Corner. No geodiversity sites have been identified in the study area.	Section 9.7 Baseline conditions

Other relevant policy and guidance

9.3.14 In addition to compliance with the NPSNN[4] and NPPF[5], this assessment has been compiled in accordance with professional standards and guidance. The standards and guidance which relate to the assessment are:

- Safeguarding our soils. A strategy for England (Department of the Environment, Food and Rural Affairs, 2009)[15].
- Department for Environment, Food & Rural Affairs (Defra) Construction Code of Practice for the Sustainable Use of Soil on Development Sites (Department for Environment, Food & Rural Affairs, 2009) [16]
- A New Perspective on Land and Soil in Environmental Impact Assessment (Institute of Environmental Management & Assessment (IEMA), 2020)[17]

9.4 Assessment methodology

9.4.1 The methodology for the geology and soils assessment follows the guidance set out within *DMRB LA 109*[1] and considers the potential impacts on:

- Bedrock geology and superficial deposits, including geological designations and sensitive/ valuable non-designated features

[15]Department of the Environment, Food and Rural Affairs (2009) Safeguarding our soils. A strategy for England
[16] Department for Environment, Food & Rural Affairs (2009) Construction Code of Practice for the Sustainable Use of Soils on Construction Sites]
[17] A New Perspective on Land and Soil in Environmental Impact Assessment (Institute of Environmental Management & Assessment (IEMA), 2020)]

- Soil resources, including Agricultural Land Classification (ALC) and Best most versatile (BMV) soils (BMV soils are ALC Grades 1, 2 and 3a);
- Human health, surface water and groundwater arising from the project's interaction with contamination.

9.4.2 Effects on geomorphology are reported in ES Chapter 10: Landscape and Visual Effects and ES Chapter 14: Road Drainage and the Water Environment, where relevant. Effects on mineral deposits as a resource are assessed in ES Chapter 11: Material Assets and Waste.

9.4.3 In accordance with *DMRB LA 109*[1] risks (Application Document 3.4) associated with geotechnical hazards and land stability are not reported within the Environmental Statement. The geotechnical risk associated with land stability is discussed within ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4) and associated *Preliminary Sources Study Report (PSSR)* (Highways England, 2019)[18].

9.4.4 The information presented in the *Preliminary Sources Study Report (PSSR)* (Highways England, 2019)[19] was reviewed as part of the environmental scoping exercise and it was identified that there is not likely to be a significant risk of Unexploded Ordnance (UXO). Therefore the risks associated with UXO were scoped out for geological purposes, as such risks will be managed as for any other construction-related risk. The UXO Desk Study and Risk assessment including Zetica Maps is included Appendix 9.4: Preliminary Source Study Report (PSSR).

Contamination assessment methodology

9.4.5 Baseline conditions of areas of potential contamination have been established through a desk-based review of publicly available information sources and through engagement with stakeholders. The A66 Northern Trans-Pennine Preliminary Environmental Information *(PEI) Report* and associated appendices (National Highways, 2021a)[20] which were completed as part of the previous phase of work, have been used to inform the baseline. In addition, a phase 1 intrusive ground investigation has been carried out along the length of the Project. The following Ground Investigation Reports (GIRs) have been used to inform the environmental impact assessment reported in this chapter, the full reports are provided in ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4):

- *A66 Northern Trans-Pennine Ground Investigation Report Package A Temple Sowerby to Brough (GIR Package A)* (National Highways, 2021b)[21]

[18] Highways England (2019) A66 Northern Trans-Pennine Project - Preliminary Sources Study Report (PSSR). [Online] 17 September 2019. HA GDMS Report Reference: 31259. HA GDMS Report Reference: 31259. HE565627-ARC-HGT-A66-RP-CE-2005
[19] Highways England (2019) A66 Northern Trans-Pennine Project - Preliminary Sources Study Report (PSSR). [Online] 17 September 2019. HA GDMS Report Reference: 31259. HA GDMS Report Reference: 31259. HE565627-ARC-HGT-A66-RP-CE-2005
[20] National Highways (2021a) A66 Northern Trans-Pennine PEI Report
[21] National Highways (2021b) A66 Northern Trans-Pennine Ground Investigation Report Package A Temple Sowerby to Brough

- *A66 Northern Trans-Pennine Ground Investigation Report Package B M6 Junction 40 to Temple Sowerby (GIR Package B)* (National Highways, 2021c)[22]
- *A66 Northern Trans-Pennine Ground Investigation Report Package C Stephen Bank to Carkin Moor and A1(M) Scotch Corner (GIR Package C)* (National Highways, 2021d)[23]
- *A66 Northern Trans-Pennine Ground Investigation Report Package D Bowes Bypass and Cross Lanes to Rokeby (GIR Package D)* (National Highways, 2021e)[24].

9.4.6 The GIRs listed above provide full details of the Human Health risk assessment carried out for each scheme. The methodology for the Human Health risk assessment is outlined in Appendix D.1 of the GIR can be found in ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4). Soil samples were collected during the ground investigation (GI) and analysed in a laboratory for a range of chemical contaminants. Soil samples from the GI include top- and sub soils, artificial ground / made ground, natural superficial and bedrock material. Laboratory results from the soil samples have been screened against Generic Assessment Criteria (GAC) based on a " Public Open Space – Park" (POSPark) land use scenario.

9.4.7 The Public Open Space (POSPark) scenario was considered to be suitable for the proposed land use under consideration. The key sensitive Human Health receptors are considered to be families with small children who may during the operational phase, break down and sit within the adjacent roadside area. This is deemed to be a relatively short-term exposure with limited contact with potentially contaminated land. Other land use scenarios include residential, commercial or allotment settings which are not appropriate for this Project. Full justification for adopting the POSpark criteria is detailed are provided in ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

9.4.8 Groundwater and surface water samples were collected during the GI and analysed at a laboratory for a range of chemical contaminants. The laboratory results have been reviewed as part of a Controlled Waters Risk Assessment (CWRA) which was undertaken as part of the GIRs. The full details of which are provided in ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4). The CWRA compared the observed chemical concentration against the lowest of available relevant Water Quality Standards (WQS) (i.e. Drinking Water Standards (DWS) or Environmental Quality Standards (EQS)). Where Tier (T1) WQS exceedances were identified, further review has been undertaken to determine whether it was possible to exclude the DWS or EQS

[22] National Highways (2021c) A66 Northern Trans-Penni HE565627-AMY-HGT-S01-RP-CE-000001_final version ne Ground Investigation Report Package B M6 Junction 40 to Temple Sowerby
[23] National Highways (2021d) A66 Northern Trans-Pennine Ground Investigation Report Package C Stephen Bank to Carkin Moor and A1(M) Scotch Corner
[24] National Highways (2021e) A66 Northern Trans-Pennine Ground Investigation Report Package D Bowes Bypass and Cross Lanes to Rokerby

receptors from the T1 assessment (e.g., due to sample type / proximity to surface water etc). Where it has been possible to exclude the DWS or EQS receptor, the T1 exceedances progressed to a more relevant Tier 2 (T2) (DWS) or T2 (EQS) assessment. The full detailed assessments are provided in ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4). A summary of the key findings is presented below in section 9.7 Baseline conditions.

9.4.9 The provisional receptor value or sensitivity has been determined with reference to Table 3.11 of *DMRB LA 109*[1] (ranging from Very High to Negligible). ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4) details the key receptors identified at this stage of assessment and their location relative to the Order Limits for the Project. The Order Limits are shown in ES Figure 9.1: Study Area (Application Document 3.3). It also outlines their assigned provisional value determined with reference to Table 3.11 of *DMRB LA 109*[1].

9.4.10 The potential magnitude of impact on the identified receptors has been determined with reference to Table 3.12 of *DMRB LA 109*[1] (ranging from major to negligible). The assessment of impact significance is based on receptor value and magnitude of effect, as detailed in *DMRB LA 104 Environmental assessment and monitoring (DMRB LA 104)* (Highways England (now National Highways), 2020)[25] using the significance matrix in Table 3.8.1. Where Table 3.8.1 includes two significance categories, evidence will be provided to support the reporting of a single significance category.

9.4.11 Significant effects are those that have a moderate impact or above. A detailed risk assessment of the identified potential significant effects has been carried out as part of this chapter.

9.4.12 Further details of the methodology for establishing baseline geology and ground conditions, and for the assessment of geodiversity, soil and contamination, are provided below.

Geological and geodiversity assessment methodology

9.4.13 The geology and ground conditions present across the study area are important in setting the context for the assessment, in terms of materials and resources present, and the potential pathways for contamination to migrate.

9.4.14 The nature and distribution of superficial deposits and bedrock across the study area has been determined through review of published geological information and historical ground investigation information, shown in Table 9-4 Geological information sources. This has been further supplemented by a Project specific ground investigation which has been completed during the first quarter of 2021. The findings of this investigation have been used to inform the assessment reported in this chapter.

[25] Highways England (now National Highways) (2020) Design Manual for Roads and Bridges LA 104 Environmental Assessment and Risk]

Table 9-4 Geological information sources

Information Source	Description of information
Primary Sources Study Report (PSSR), see ES Appendix 9.4: Preliminary Source Study Report (Application Document 3.4).	Information is provided on former and current land uses, geology, hydrogeology, statutory designations, mining, landfills and earthworks together with a geo-environmental preliminary conceptual site model
Desk Study – Karst Risk Assessment (National Highways)[26]	Provides information on karst and dissolution features across A66 schemes, and assesses risks based on underlying geology
BGS GeoIndex (British Geological Survey, 2021) [27]	Published historical borehole logs available online, provided by the BGS
British Geological Survey (BGS) Mapping (British Geological Survey, 2021)[28]	Solid and drift mapping across the scheme to 1:50,000 scale including details of the type of bedrock present and superficial deposits including peat, alluvium and glacial till
Coal Authority Viewer (Coal Authority, 2021)[29]	Information is provided on past and current recorded coal mining activities, at surface (opencast) and depth (underground)
Technical Note HE565627-AMY-EGTS00-RP-LG-000001 (Amey, 2021)[30]	This short technical note gives a very brief summary of geotechnical conditions across the western half of the project as encountered during the 2021 ground investigation.

9.4.15 Geodiversity impacts could occur as a result of direct loss of, or damage to, important sites as a result of development. Geodiversity sites can also be impacted through changes to the local hydrogeology, as reported in Chapter 14: Road Drainage and the Water Environment.

9.4.16 The geodiversity data sources, stakeholder engagement and a description of the information sought or obtained from each are summarised in Table 9-5: Geodiversity information sources.

Table 9-5: Geodiversity information sources

Information Source	Description of information
Data sources	
Defra Multi-Agency Geographic Information for the Countryside (MAGIC) website (Multi-Agency Geographic Information for the Countryside, 2020)[31]	Provides information on geological conservation areas such as SSSI and Geological Descriptions.

[26] National Highways A66 NTP Integrated Project Team. (no date). Desk Study – Karst Risk Assessment. Ref. HE565627-AMY-EGT-S00-RP-LG-000005
[27] British Geological Survey (2022) GeoIndex Onshore online viewer]
[28] British Geological Survey (2021) Mapping
[29] Coal Authority (2021) Interactive Map]
[30] Amey (2021) Technical Note HE565627-AMY-EGT-S00-RP-LG-000001
[31] Multi-Agency Geographic Information for the Countryside (2020) Interactive Map]

Information Source	Description of information
Cumbria geoconservation interactive mapping (Cumbria Biodiversity Data Centre, 2020[32]	Provides information on LGSs in Cumbria.
North Pennines AONB website (North Pennines, 2020)[33]	Provides information on the UNESCO Global Geopark, located in the North Pennines AONB.
Stakeholder engagement	
North Pennines AONB, telecon February 2021	Consultation aimed to determine requirements in relation to the UNESCO Global Geopark designation.
BGS, telecon December 2020	BGS confirmed that they do not hold the details of designated geoconservation sites.

9.4.17 The geodiversity baseline study has identified the location and the reason for designation of geologically designated sites within the study area. Geodiversity sites include non-designated site of local importance, SSSI, Local Geology Sites (LGS) (formerly Regionally Important Geological Sites (RIGS), GCR sites and UNESCO Global Geoparks.

9.4.18 The geodiversity baseline study has identified the presence of geological designations within the study area and attributed the receptor sensitivity or valuable to the geological designated features. The receptor value or sensitivity has been determined with reference to Table 3.11 of DMRB LA 109[1] (ranging from Very High to Negligible).

9.4.19 The magnitude of the impact has been assessed using Table 3.12 of DMRB LA 109[1] (ranging from Major to No change). In order to assess the magnitude of the impact, the Project considered the construction and operational design and assessed the temporary and permanent effects.

9.4.20 The assessment of impact significance is based on receptor value and magnitude of effect, as detailed in *DMRB LA 104 Environmental assessment and monitoring (DMRB LA 104)* (Highways England (now National Highways), 2020)[34] using the significance matrix in Table 3.8.1.

9.4.21 The UNESCO Global Geopark is located within the Project Order Limits and is attributed to the highest receptor value (very high) and is of international importance with no potential for replacement.

9.4.22 Significant effects are those that have a moderate impact or above. A detailed risk assessment of the identified potential significant effects has been carried out as part of this chapter.

[32] Cumbria Biodiversity Data Centre (2020) Cumbria GeoConservation - Geological Sites Map,]
[33] North Pennines (2020) North Pennines Area of Outstanding Natural Beauty]
[34] Highways England (now National Highways) (2020) Design Manual for Roads and Bridges LA 104 Environmental Assessment and Risk]

Soils assessment methodology

9.4.23 Baseline soil conditions are further informed by the Project soil resource survey.

9.4.24 Impacts on soil could occur as a result of the loss of agricultural land or as a result of degradation to or loss of soils through processes such as compaction, contamination, mixing or erosion. Such impacts may affect agriculture and sensitive habitats. The land was classified using the system outlined in the Agricultural Land Classification of England and Wales - Revised guidelines and criteria for grading the quality of agricultural land (Ministry of Agriculture, Fisheries and Food (MAFF), now Department for Environment Food and Rural Affairs, 1988)35. Notwithstanding the age of this document, it remains the industry accepted publication.

9.4.25 The Agricultural Land Classification (ALC) system provides a framework for classifying land according to the extent to which its physical or chemical characteristics impose long-term limitations on agricultural use.

9.4.26 The presence and classification of the agricultural soils and soils supporting ecological valuable sites within the study area has been determined through a review of published information. This has been further supplemented by a Project specific soil survey which has been carried out within the Order Limits.

9.4.27 The soils data sources, stakeholder engagement and a description of the information sought or obtained from each are summarised in Table 9-6: Soils information sources.

Table 9-6: Soils information sources

Data sources	
MAFF Provisional ALC Maps	The Provisional ALC maps (Ministry of Agriculture, Fisheries and Food, 1970s)36. The Provisional Maps give an indication of land quality at the strategic planning scale but should not be relied on for site specific assessment of land quality. In addition, land that is classified as Grade 3 is not categorised into Grade 3a and Grade 3b to differentiate between the 'best and most versatile' (BMV) i.e., better quality land (Grade 1 to Grade 3a) and lower quality land (Grade 3b to Grade 5).
Natural England Strategic ALC Maps (Natural England, 2021)37	ALC Strategic Map Information. The Strategic Map Information is based on Natural England predictions of the likelihood of BMV agricultural land (i.e., ALC Grades 1, 2 and 3a.

[35] Ministry of Agriculture, Fisheries and Food (1988) Agricultural Land classification of England and Wales]
[36] Ministry of Agriculture, Fisheries and Food (1970) Provisional Agricultural Land Classification (ALC) Maps.]
[37] Natural England (2021) Regional Agricultural Land Classification Maps]

Data sources	
British Geological Survey Maps [27]	These maps provide information of solid and superficial geology which have an effect on soil type and therefore on land quality.
Natural England Detailed ALC Surveys	The Defra MAGIC[31] website provides post-1988 subdivision survey digital data on detailed ALC surveys undertaken by Natural England. This information provides a definitive grade for the land and has been used as the primary source of information where available.
Soils of Northern England (NHBS, 2021) 38 1:250,000 scale map	Soils of Northern England 1:250,000 scale map. This map provides baseline information about soil associations i.e. provides information soils which occur together in the landscape.
Stakeholder engagement	
Natural England, April 2021	The purpose of consultation was to agree an approach to the ALC methodology with Natural England as much as possible. Notable points NE wanted to consider were the identification of ALC for the draft DCO boundary, identifying the constraints and what is the best use of the soil i.e., reuse where applicable. It was noted by Natural England that: areas of peatland are adjacent to the route; and a distinction should be made between the temporary and permanent land take which would result in the loss of soil

9.4.28 In order to confirm the published information, a soil and ALC survey was carried out by soil survey specialist ADAS between 7 February and 15 March 2022 across the Order Limits. The survey methodology followed the well-established guidelines set out in the Agricultural Land Classification of England and Wales, Revised guidelines and criteria for grading the quality of agricultural land, issued by the former Ministry of Agriculture, Fisheries and Food (MAFF) in 1988[33].

9.4.29 The survey included the examination of soil profiles at 100m intervals on land corridors or at intersects of a 100m grid on larger blocks of land using hand-held augers and spades. Soil cores were extracted and examined in order to characterise the soil profiles and allocate ALC Grade. Occasional pits were dug in representative soil types to confirm auger boring findings particularly in relation to soil structure and stone

[38] NHBS (2021) Soil Survey of England and Wales, Sheet 1: Northern England

content. The survey was based on observations at intersects of a 100m grid, giving a sampling density of one observation per hectare.

9.4.30 The following characteristics were assessed for each soil horizon up to a maximum depth of 120cm or any impenetrable layer:

- soil texture;
- stone content;
- soil colour (including matrix, ped face and mottle colours);
- consistency;
- structural condition (where profile examination pits dug);
- free carbonate; and
- soil horizon depths.

9.4.31 Soil texture assessment was carried out by hand texturing with confirmation on selected representative samples by laboratory particle size distribution analysis using the pipette method.

9.4.32 The soil characteristics identified and described were then used to allocate the ALC Grade according to the MAFF (now Defra) 1988[33] guidelines and the sensitivity allocated according to Table 3.11 of *DMRB LA 109*[1] (ranging from Very High to Negligible), as detailed in Section 9.4 Assessment methodology. Table 9-7 Agricultural Land Classification (ALC) of England & Wales: Revised guidelines and criteria for grading the quality of agricultural land presents the criteria for the ALC grades.

Table 9-7 Agricultural Land Classification (ALC) of England & Wales: Revised guidelines and criteria for grading the quality of agricultural land

ALC/ soil	ALC Quality	Description (type, limitations, typical cropping range and yields)	DMRB Receptor Value (Sensitivity)
Grade 1	Excellent quality agricultural land	Land with no or very minor limitations to agricultural use. A very wide range of agricultural and horticultural crops can be grown and commonly includes top fruit, soft fruit, salad crops and winter harvested vegetables. Yields are high and less variable than on land of lower quality.	Very High
Grade 2	Very good quality agricultural land	Land with minor limitations which affect crop yield, cultivations or harvesting. A wide range of agricultural and horticultural crops can usually be grown but on some land in the grade there may be reduced flexibility due to difficulties with the production of the more demanding crops such as winter harvested vegetables and arable root crops. The level of yield is generally high but may be lower or more variable than Grade 1.	Very High
Grade 3	Good to moderate quality agricultural land	Land with moderate limitations which affect the choice of crops, timing and type of cultivation, harvesting or the level of yield. Where more demanding crops are grown yields are generally lower or more variable than on land in Grades 1 and 2.	High

ALC/ soil	ALC Quality	Description (type, limitations, typical cropping range and yields)	DMRB Receptor Value (Sensitivity)
Subgrade 3a	Good quality agricultural land	Land capable of consistently producing moderate to high yields of a narrow range of arable crops, especially cereals, or moderate yields of a wide range of crops including cereals, grass, oilseed rape, potatoes, sugar beet and the less demanding horticultural crops.	
Subgrade 3b	Moderate quality agricultural land	Land capable of producing moderate yields of a narrow range of crops, principally cereals and grass or lower yields of a wider range of crops or high yields of grass which can be grazed or harvested over most of the year.	
Grade 4	Poor quality agricultural land	Land with severe limitations which significantly restrict the range of crops and/or level of yields. It is mainly suited to grass with occasional arable crops (e.g. cereals and forage crops) the yields of which are variable. In moist climates, yields of grass may be moderate to high but there may be difficulties in utilisation. The grade also includes very droughty arable land.	Medium
Grade 5	Very poor quality agricultural land	Land with very severe limitations which restrict use to permanent pasture or rough grazing, except for occasional pioneer forage crops.	Low
Descriptions of other land categories used on ALC maps			
Non-agricultural		Soft' uses where most of the land could be returned relatively easily to agriculture, including: golf courses, private parkland, public open spaces, sports fields, allotments and soft-surfaced areas on airports/ airfields. Also active mineral workings and refuse tips where restoration conditions to 'soft' after-uses may apply.	Negligible
Urban		Built-up or 'hard' uses with relatively little potential for a return to agriculture including: housing, industry, commerce, education, transport, religious buildings, cemeteries. Also, hard-surfaced sports facilities, permanent caravan sites and vacant land; all types of derelict land, including mineral workings which are only likely to be reclaimed using derelict land grants.	Negligible

Contamination assessment

Potential sources

9.4.33 Contamination impacts could occur if historic and existing contamination is disturbed or mobilised by the Project, resulting in sensitive receptors being exposed to contamination. This could be as a result of existing pollutant linkages, or the creation of new pollutant linkages.

9.4.34 Key potentially contaminative historical land uses and historic mapping within the study area are presented within ES Appendix 9.4: Preliminary Source Study Report (Application Document 3.4). The results have been used to inform the assessment presented in this ES.

9.4.35 The contamination assessment has considered the presence of potential sources of contamination associated with former and current land uses. Based on the desk study information, a full list of potential sources is provided in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4), the type of land considered include:

- Current and historical landfill sites
- Current and historical mineral extraction sites
- Licensed waste management sites
- Current and historical industrial or commercial sites
- Discharges to surface and groundwater
- Foot and mouth disease (FMD) burial sites
- Farmyards
- Ministry of Defence land
- Operational and disused railway lines and railway land
- Sewage treatment works
- Cemeteries.

9.4.36 Each potential contamination source identified has been given its own unique identifier (e.g., CL01-15, where 01 refers to the scheme reference number and 15 refers to a unique potential contaminant source) and has been classified in terms of its likely contamination potential, using guidance published by the Homes and Communities Agency (Homes and Communities Agency, 2013)[39]. This guidance assigns a “low, moderate or high” risk rating to potential for contamination and categorises sites according to their use. Low risk sites are those which are classed as having a low risk of potential contamination, or less hazardous chemicals such as farms or light commercial business, to high-risk sites of high potential contamination with hazardous chemicals likely to be present, such as Landfills chemical work s or fuel stations, for example. Full details are provided in Table 1 2: Potentially contaminative land uses, ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

9.4.37 Professional judgement has been applied where a potential contamination source has had multiple uses, for example:

- a historical industrial building that had high potential for contamination but has since been converted into a residence and is therefore considered likely to now have a low contamination potential, or

[39] Homes and Communities Agency (2013) Guidance on dereliction, demolition and remediation costs (3rd edition),]

- a former quarry which had low contamination potential was later used as a landfill site and is now likely to have a high contamination potential.

9.4.38 A two-stage screening process has been carried out for the identified potential contamination sources. The first stage , considers the potential for each source to feasibly be disturbed or mobilised by the Project. Each of the potential sources within the Geology and soils study area have been identified in the ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4) and on ES Figure 9.5: Potential Contamination Sources (Application Document 3.3). This has taken into account:

- the location of the source in relation to the Order Limits boundary, with sources within the Order Limits being most likely to be impacted.
- the nature of the Project in the vicinity of the source, with sources outside the Order Limits boundary only likely to be impacted in areas where groundwater flow may be affected. This considered areas of deep cuttings or groundwater control during construction.
- the likely type and form of contaminants present, with less mobile contaminants being less likely to be impacted by any changes to groundwater flow as a result of the project.

9.4.39 The assessment has considered soil contamination, groundwater contamination and ground gas sources in line with DMRB.

9.4.40 Contamination sources that have not been screened out in the first stage were moved on to the second stage of the screening process and assessed in this chapter. The sources were assessed against the Order Limits. The assessment is based upon the source-pathway-receptor principle, as set out in the Land Contamination: Risk Management (LCRM) guidance (Environment Agency, 2020)[40]. The assessment has considered:

- the likely type, form and levels of contaminants present.
- the location, proximity and type of sensitive receptors in the vicinity of the contamination source.
- the potential pathways for exposure that could arise from or be exacerbated by the Project.

9.4.41 The potential sources are summarised in ES Figure 9.5: Potential Contamination Sources (Application Document 3.3) and ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). It should be noted that a reasonable worst-case has been assumed for the screening assessment, in the absence of information to verify desk-based sources. Where further information has not been made available such sites have been given a higher risk rating. The assessment has been carried out based on a higher risk and appropriate mitigation measures.

[40] Environment Agency (2020) Land Contamination: Risk Management

Potential receptors

9.4.42 The assessment has identified receptors that could be exposed to any contamination, including the health of people living in, working in or otherwise using the study area ('human health') and the quality of groundwater and surface watercourses, geological sites and soils.

9.4.43 The identified sources, pathways and receptors are presented in the form of the conceptual site model (CSM) showing the potential contaminant linkages, as set out in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). The potential impacts of the Project were assessed by comparing the risk levels at baseline with the CSM and the risk levels for the construction and operation stages respectively, in order to determine any change in risk at each stage.

9.4.44 Where designated ecological receptors are identified such as Eden Special Area of Conservation (SAC) and the River Eden Tributaries Site of Special Scientific Interest (SSSI, this chapter only considers the soils which support the ecological designation, in line with *DMRB LA 109*[1]. Chapter 6: Biodiversity considered the ecological receptors further.

9.4.45 The potential for significant effects, is shown later in this chapter and summarised in Table 9-39: Summary of significant effects (construction), to these receptors has been considered and assessed based on the *DMRB LA 109*[1] Sensitivity/value of receptors and magnitude criteria and are presented in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

In-combination climate change assessment methodology

9.4.46 An in-combination climate change assessment has been conducted to assess likely changes to the significance of effects when considering the combined impact of future climate on the Projects groundwater, surface water, soils, geology, and human health receptors in the surrounding environment. The assessment considers whether climate change could impact the likelihood and magnitude of the effects of the Project on the groundwater, surface water, soils, geology, and human health receptors, or affect the susceptibility, vulnerability, value or importance of the receptors themselves. The assessment has been based on the latest *UK Climate Projections 2018* (UKCP)[41] and considers a range of climatic hazards including rising temperatures, higher and lower rainfall, and the increased frequency and magnitude of extreme events such as heat waves and flooding.

Scoping

9.4.47 Table 9-8: Summary of Scoping Opinion and response, sets out the key points from the Planning Inspectorate Scoping Opinion relevant to the

[41] Regional UKCP18 projections for the 2060s reflecting RCP 8.5 high emission scenario. Met Office (2018) UK Climate ProjectionsIn accordance with DMRB LA 114, all UKCP18 projections used in the assessment reflect the high emissions scenario, representative concentration pathway 8.5 (RCP8.5) for the 2060s against a baseline period of 1981-2010.

geology and soils assessment. The full Scoping Opinion is provided in ES Appendix 4.2: EIA Scoping Opinion (Application Document 3.4).

9.4.48 Where an assessment has been undertaken in accordance with the Scoping Opinion, the wording of each point raised with a response and reference to the relevant ES section is provided. Where further discussion and/or an alternative approach has been agreed with the relevant stakeholders and the planning inspectorate, an explanation is provided.

Table 9-8: Summary of Scoping Opinion and response

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
Durham County Council (DCC),	Some sites of potential land contamination have been identified within the study area, including landfilling. Although the risks posed to the end user are low, Made Ground and contamination will need to be identified and dealt with accordingly. The council recommends pre-construction contaminated land conditions should be imposed to ensure information compliant with the Yorkshire and Lincolnshire Pollution Advisory Group (YALPAG) Guidance (Yorkshire and Lincolnshire.	The applicant has obtained necessary information to inform the baseline such th at the assessment is carried out in line with the Yorkshire and Lincolnshire Pollution Advisory Group (YALPAG) Guidance document. The (YALPAG) guidance document is consistent with the Environment Agency LC:RM guidance, which this chapter adheres to. Potentially contaminated sites identified at baseline and further information has been obtained from ground investigations. Mitigation measures have been designed to include procedures to be implemented in the event that contamination is identified. Such measures, are specified in the Environmental Management Plan (EMP).	Section 9.7: Baseline conditions Section 9.9: Essential mitigation and enhancement measures EMP (Application Document 2.7)
Environment Agency	Approach and methodology proposed is considered to be appropriate. No objection raised to proposed baseline based on desk-based information, although requested all receptors are identified.	Baseline information has been supplemented through further enquiries to key stakeholders.	Section 9.7: Baseline conditions Receptors identified in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
Natural England	Natural England welcomes the use of the assessment methodology set out in *DMRB LA 109*[1]. Natural England welcomes the proposal to prepare an Environment Management Plan (EMP) containing soil mitigation measures in line with the Defra Construction Code of Practice for the Sustainable Use of Soil on Development Sites (Department for Environment, Food & Rural Affairs, 2009)[16]	*DMRB LA 109*[1] has been used to as the assessment methodology. An Environmental Management Plan (EMP) has been prepared and mitigation measures appropriate to geology and soils have been included. The Defra Construction code of Practise for the use of sustainable soils has been adopted.	Section 9.8: Potential impacts; EMP (Application Document 2.7)
Natural England	NE agreed the approach to the Agricultural Land Classification (ALC) methodology with Natural England. Natural England noted that areas of peatland are adjacent to the Project; and a distinction should be made between the temporary and permanent land take which would result in the loss of soil.	An assessment of agricultural and soil resource of the site has been undertaken. The assessment is based on desk study information and a soil survey which has taken place within the Order Limits. The soil survey has identified the ALC Grades and recorded the peat, where present . Methods for restoring land impacted by the temporary construction activities have been considered in this chapter. An aftercare programme, enabling a satisfactory standard of agricultural after-use to be reached will also be in place.	Section 9.6: Study area Section 9.7: Baseline conditions Section 9.8: Potential impacts Section 9.9: Essential mitigation and enhancement measures EMP (Application Document 2.7)
North Pennines AONB	Consultee noted the presence of UNESCO Global Geopark designation and the AONB. The consultee raised that is a requirement to assess the UNESCO Global Geopark	It is acknowledged that the AONB and UNESCO Global Geopark have the same site boundary. AONB are not identified as geology and soils receptor in accordance with DMRB LA 109[1] guidance. This chapter considers the	Section 9.6: Study area Section 9.8: Potential impacts

Consultee/ respondent	Scoping opinion comment	Applicant response	Where addressed?
	within the Geology and soils chapter.	UNESCO Global geopark which has very high receptor sensitivity according to DMRB LA 109[1]. The AONB is considered in Chapter 10: Landscape and visual.	Section 9.9: Essential mitigation and enhancement measures

Consultation

9.4.49 Table 9-9: Summary of key consultation comments received sets out the key points from consultation with stakeholders relevant to geology and soils assessment. Table 9-9: Summary of key consultation comments received also sets out how the ES has responded to the comment received and where in this chapter the comment is addressed.

Table 9-9: Summary of key consultation comments received

Consultee/ respondent	Comment	Applicant response	Where addressed?
Eden District Council	The Councils were contacted regarding the potential presence of foot and mouth burial sites. Eden District council provided a list of recorded sites for the County.	The Foot and mouth burial sites have been reviewed and a detailed risk assessment has been carried out in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). Mitigation measures are secured in the EMP (Application Document 2.7).	Section 9.8: Potential impacts Section 9.9: Essential mitigation and enhancement measures EMP (Application Document 2.7)
Environment Agency	The Environment Agency was contacted identify any potential contamination concerns and, where appropriate, obtain further information on landfill sites to supplement other baseline data.	Baseline information has been supplemented through further enquiries to key stakeholders.	Section 9.7: Baseline conditions Receptors identified in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).
Animal and Plant Health Agency (APHA),	Confirmed no recorded animal burial sites are within the study area but	Mitigation is included in EMP, for implementation in the event that animal burials are encountered during construction of the Project.	Section 9.9: Essential mitigation and

Consultee/ respondent	Comment	Applicant response	Where addressed?
email dated 17 February 2021	noted that their records are incomplete. Requested a formal process is implemented in the event that animal carcasses are discovered during construction.		enhancement measures EMP (Application Document 2.7)
British Gypsum	British Gypsum was contacted for further details of gypsum mining and any associated land quality issues to supplement existing baseline data.	Baseline information has been supplemented through further enquiries to key stakeholders.	Section 9.7: Baseline conditions ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).
Ministry of Defence (MoD)	The MOD was contacted further details of any potential contamination issues at Warcop training camp.	Baseline information has been supplemented through further enquiries to key stakeholders	Section 9.7: Baseline conditions ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

9.5 Assumptions and limitations

9.5.1 The ES has been based upon desk top review of available data sources, Project specific ground investigation and soil survey.

9.5.2 A number of proposed exploratory hole locations were not surveyed as access was not granted largely due to the presence of livestock in the fields. Actual site conditions for such areas have therefore not been confirmed. Professional judgement has been applied to such areas based on desk-based information including geological, soil and historical mapping. Assumptions have been made on the potential for contamination based on the historical and current land use and geology and soil type.

Contamination

9.5.3 The assessment of contamination is based on available desk study information, public and private records and ground investigation information. There is the potential that further localised sources of contamination could be present over and above those identified as part of the assessment. These could, for example, be associated with localised fill materials, spillages or waste deposition. Whilst the assessment cannot consider such unknown sources, mitigations to manage the potential impacts of any such contamination are set out in Section 9.9: Essential mitigation and enhancement measures and secured in the EMP. Mitigation measures will include a Phase 2 targeted ground investigation to provide more detailed information.

9.5.4 The contaminant types included within the risk assessments, presented in this chapter, are based on known land use and the *'Industry Profiles'* series of documents (Department for the Environment, 2021)[42] where available.

Soils

9.5.5 During the ALC soil survey access was not possible to certain locations due to the presence of livestock. The timing of the survey coincided with lambing season. Access was only available to fifteen percent of the survey positions at the Cross Lanes to Rokeby scheme. However, a sufficient number of representative positions were surveyed, across the Order Limits, which allowed an overall value for land classifications. This is based on the Natural England guidance which defines one observation hole per ha (or one observation per 100m on narrow strips of land as for a road route).

9.5.6 The Table 9-10 Number and percentage of proposed survey positions surveyed/not surveyed below shows the number and percentage of the proposed ALC data collection positions surveyed and not surveyed. The ALC survey data has been collated and used to inform the soil assessment.

Table 9-10 Number and percentage of proposed survey positions surveyed/not surveyed

Scheme	Positions Surveyed		Positions Not Surveyed	
	Number	% (of total)	Number	% (of total)
M6 Junction 40 to Kemplay Bank	23	79	6	21
Penrith to Temple Sowerby	112	86	18	14
Temple Sowerby to Appleby	196	93	14	7
Appleby to Brough	147	92	12	8
Bowes Bypass	16	94	1	6
Cross Lanes to Rokeby	9	15	53	85
Stephen Bank to Carkin Moor	80	98	2	2

[42] Department for the Environment (2021) Industry Profiles

9.5.7 The A1(M) Junction 53 Scotch Corner scheme was not included in this ALC survey due to the limited proposed works in this area and the existing nature of the soil environment. The Project at this location is largely within existing highway environment. The land affected by this scheme is mostly non-agricultural and urban, with little potential to return to agriculture.

Mitigation

9.5.8 The construction and operation assessments assume that embedded mitigation measures are applied and that standard best practice measures are implemented during construction to prevent contamination. It is assumed that measures would be applied through the EMP and through working in accordance with *Construction Industry Research and Information Association (CIRIA) C741 4th Edition Environmental Good Practice on Site* (Construction Industry Research and Information Association, 2015)[43]. The EMP and CIRIA guidance documents provide details for the personal protective equipment that shall be worn during construction works and as such the risk to construction workers is excluded from the assessment. The essential mitigation measures are described in more detail in section 9.9: Essential mitigation and enhancement measures.

9.6 Study area

9.6.1 The study area for the geology and soils assessment is a 250m buffer beyond the Order Limits, as shown in ES Figure 9.1: Study Area (Application Document 3.3). Where sensitive surface water and groundwater receptors such as abstractions are present, these have been considered within a 1km buffer of the Order Limits, in line with the approach adopted in ES Chapter 14: Road Drainage and the Water Environment.

9.6.2 The study area of 250m is considered best practise and fully informed by the identified baseline conditions and location of potential receptors in the area. Industry guidance does not provide a definitive study area. 250m is in line with the requirements of Paragraph 3.5 of *DMRB LA 109*[1] i.e., it is sufficient to ensure that any sources of contamination that could migrate and any sensitive receptors that could be affected by the Project can be appropriately identified.

9.6.3 The 250m study area is considered sufficient, relevant and appropriate for the potential for significant environmental effects related to geology and soils in the context of this Project. Significant contamination and ground gas is not anticipated to travel over 250m and is unlikely to cause significant risk to receptors.

[43] Construction Industry Research and Information Association (2015) Environmental good practice on site guide. 4th Edition.

9.7 Baseline conditions

The Project

9.7.1 A summary of the project-wide baseline conditions is presented below, followed by scheme-by-scheme specific information.

Geological context

9.7.2 Published geological mapping (British Geological Survey, 2022) indicates that the study area is expected to be underlain by Made Ground of varying thicknesses, overlying natural superficial deposits including Alluvium comprising mixtures of sand, silt and clay associated with watercourses, Glaciofluvial deposits comprising sands and gravels, and Glacial Till, comprising clay with layers of sand, gravel and cobbles. Glacial meltwater channels and drumlin features are present in the Penrith to Temple Sowerby area.

9.7.3 Peat is noted in some areas including M6 Junction 40 to Kemplay Bank, Penrith to Temple Sowerby, Temple Sowerby to Appleby, Appleby to Brough and Bowes Bypass. The published superficial geology is shown in ES Figure 9.2: Published Geology - Superficial Geology (Application Document 3.3).

9.7.4 The bedrock geology comprises of Carboniferous age sandstones, siltstones, mudstones, limestones and some coals west of Penrith and from Brough to the A1 at Scotch Corner. The main western section from Penrith to Brough comprises of Permian aged, sandstones and shales.

9.7.5 The Carboniferous strata comprises of the Stainmore Formation (mudstone, siltstone and sandstone), the Great Limestone Member (limestone member of the Alston Formation), the Alston Formation (limestone, sandstone, siltstone and mudstone) and Four Fathom Limestone Member (limestone member of the Alston Formation).

9.7.6 All of the limestone formations within the study area have the potential to form karstic features, such as enclosed depressions, caves and springs. The Great Limestone Member includes a number of significant karst features in the area, including caves. The other limestone units have the potential for dissolution but those karst features in the area are generally small scale.

9.7.7 An assessment of potential karst risk to the Project has been undertaken and is discussed in detail in Chapter 14 Road Drainage and the Water Environment.

9.7.8 The assessment provides a review of existing public databases, documents, and publications of karst occurrence across the Project, and subsequently uses LIDAR ground elevation data to screen where surface karst features may be present. In the vicinity of Kirkby Thore, the Penrith Sandstone Formation is overlain by the Eden Shales Formation. There are several shallow gypsum beds within the Eden Shales Formation and karstic features have been identified in these. The shallow nature of the gypsum deposits indicates a significant karst risk where the road crosses these unit.

9.7.9 The Carboniferous limestones which are present in the Bowes Bypass and Cross Lanes to Rokeby schemes, were assessed to have moderate karst risk.

9.7.10 The published bedrock geology is shown in ES Figure 9.3: Published Geology - Bedrock Geology (Application Document 3.3).

9.7.11 Surface coal resources are present in the east from M6 Junction 40 to Appleby. The Project does not lie within any Coal Mining Reporting Area. There is a mineshaft recorded approximately 400m south-west of the Order Limits, and outside the study area in the Stephen Bank to Carkin Moor scheme and is associated with cooper mines. There are no reported mine workings within the Order Limits itself.

9.7.12 There is a Mineral Safeguarding Area (MSA) for gypsum deposits in the Long Marton and Kirkby Thore area where British Gypsum operates an existing mine and plasterboard factory.

9.7.13 Further details regarding the mineral resources are provided in Chapter 11 Material assets and waste.

Geodiversity

9.7.14 The study areas for the Appleby to Brough and Bowes Bypass schemes include part of the North Pennines UNESCO Global Geopark. The Geopark area is the same as that of the North Pennines AONB. The geological designated sites are shown on ES Figure 9.4: Geodiversity Sites (Application Document 3.3).

Soil

9.7.15 A number of published data sources, as detailed in Section 9.4 Assessment Methodology above, have been drawn upon in order to establish the broad baseline conditions relating to geological, topographical, soil and agro-climatic information for the Site.

9.7.16 The majority of soils in the study area are Agricultural Land Classification (ALC) Grade 3a and 3b. There is some Grade 2 agricultural land, non-agricultural land and urban land within the study area. The published Agricultural Land Classification is shown in ES Figure 9.6: Agricultural Land Classification (Application Document 3.3).

9.7.17 In order to verify the published information, a soil and ALC survey was carried out by ADAS between 7 February and 15 March 2022 across the open areas within the Geology and Soils study area. The survey methodology followed the well-established guidelines set out in the Agricultural Land Classification of England and Wales, Revised guidelines and criteria for grading the quality of agricultural land, issued by the former Ministry of Agriculture, Fisheries and Food (MAFF) in 1988[33].

9.7.18 The survey included the examination of soil profiles at 100m intervals on land corridors or at intersects of a 100m grid on larger blocks of land using hand-held augers and spades. Soil cores were extracted and examined in order to characterise the soil profiles and allocate ALC Grade. Occasional pits were dug in representative soil types to confirm

auger boring findings, particularly in relation to soil structure and stone content. The survey was based on observations at intersects of a 100 m grid, giving a sampling density of one observation per hectare.

9.7.19 The following characteristics were assessed for each soil horizon up to a maximum depth of 120 cm or any impenetrable layer:

- Soil texture
- Stone content
- Soil colour (including matrix, ped face and mottle colours)
- Consistency
- Structural condition (where profile examination pits dug)
- Free carbonate
- Soil horizon depths.

9.7.20 Soil texture assessment was carried out by hand texturing with confirmation on selected representative samples by laboratory particle size distribution analysis using the pipette method.

9.7.21 The soil characteristics identified and described were then used to allocate the ALC Grade according to the MAFF (now Defra) 1988 guidelines[33].

Contamination sources

9.7.22 A number of potentially contaminative sites have been identified within the study area, including railway land, disused quarries, landfill sites, industrial land uses and farms. The full list of potentially contaminated sites is presented in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). The potentially contaminated sites identified with the study area are shown on ES Figure 9.5: Potential Contamination Sources (Application Document 3.3).

Contamination receptors

9.7.23 A number of potential contamination receptors have been identified within the study area. Potential human receptors include residential properties, schools, allotments, public open spaces, industrial and commercial land uses. Water receptors include aquifers, groundwater abstractions and surface water bodies. Areas of the scheme lie within a Source Protection Zones (SPZ) 3 associated with the Environment Agency licensed abstractions. SPZ1 and 2 areas are located 2km south at the eastern end of the Penrith to Temple Sowerby alignment.

9.7.24 Designated ecological receptors are the River Eden Special Area of Conservation (SAC) and the River Eden Tributaries Site of Special Scientific Interest (SSSI). The soil which supports these sites has been considered in this chapter.

Ground investigation

9.7.25 A ground investigation was carried out within the Project area from 1 February 2021 to 28 April 2021. A GIR has been produced for each scheme. The key findings from the ground investigation, relevant to this

chapter, are summarised below. The full details of the investigation and findings are provided in the following documents, and are provided in ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4):

- *GIR Package A-Temple Sowerby to Appleby and Appleby to Brough*
- *GIR Package B-M6 Junction 40 to Kemplay Bank and Penrith to Temple Sowerby*
- *GIR Package C-Stephen Bank to Carkin Moor and A1(M) Junction 53 Scotch Corner*
- *GIR Package D* -Bowes Bypass and Cross Lanes to Rokeby.

M6 Junction 40 to Kemplay Bank

Geological context

9.7.26 The study area is indicated to be underlain by Made Ground overlying natural superficial deposits comprising Alluvium, River Terrace Deposits, Glacial Till, Glaciofluvial Deposits and Undifferentiated Glacial Deposits. The existing A66 alignment is situated on embankments, within cuttings and at-grade. Consequently, extensive engineered fill and/or reworked natural ground is anticipated in areas of the embankments.

Geodiversity sites

9.7.27 No geodiversity sites have been identified in the study area.

Contamination sources

9.7.28 Potentially contaminative sites have been identified which could be impacted by, and / or impact the Project. These include railway lines, a disused quarry, a historical landfill, industrial sites and farms, as detailed in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). The potential contaminated sites for this scheme are prefixed CL01- and CL02 in the appendix.

Contamination receptors

9.7.29 A number of potential contamination receptors have been identified in the study area. These include residential properties, industrial estates and recreation areas, a principal aquifer and groundwater abstractions and surface waters including Thacka Beck and the River Eamont. Further information on groundwater and surface water receptors is provided in ES Chapter 14: Road Drainage and the Water Environment and in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

9.7.30 There are two designated ecological receptors within the study area, the River Eden SAC and the River Eden and Tributaries SSSI. Further detail on these statutory designated sites, and their qualifying habitats and vegetative communities, is provided in Chapter 6: Biodiversity.

Ground investigation

9.7.31 A programme of ground investigation took place between 15 February 2021 and 28 April 2021 and comprised 24 cable percussion boreholes to a maximum depth of 10.05m, 10 cable percussion boreholes extended by rotary coring to a maximum depth of 15.50m, nine hand excavated inspection pit to a maximum depth of 0.90m, four sonic drilled boreholes to a maximum depth of 25.73m, 33 machine excavated trial pits to a maximum depth of 3.80m, 11 hand excavated trial pits to a maximum depth of 1.50m, and two window sample boreholes to a maximum depth of 4.80m. The exploratory hole location plan is provided in Appendix E – Final Factual Report of ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

Encountered ground conditions

9.7.32 A summary of the encountered ground conditions during the ground investigation within the study area is provided in Table 9-11: Summary of proven geology and ground conditions: M6 Junction 40 to Kemplay Bank.

Table 9-11: Summary of proven geology and ground conditions: M6 Junction 40 to Kemplay Bank

Strata	Proven depth range (m bgl)	Description
Superficial		
Topsoil	0.00-1.20	Sandy gravelly Clay or a Sand with rootlets.
Made Ground-Cohesive	0.00-3.55	Stiff dark brown sandy gravelly CLAY with low cobble content.
Made Ground-Granular	0.00-3.65	Dark brown slightly gravelly fine to coarse SAND with occasional roots and rootlets.
Granular Glacial Till	0.20-13.95	Clayey gravelly SAND and less often as clayey sandy GRAVEL
Fluvioglacial Till	0.25-25.67	Dense brown clayey gravelly fine to coarse SAND with low cobble content.
Cohesive Glacial Till-Sandy	0.10-25.73	Gravelly clayey SAND or gravelly sandy CLAY.
Cohesive Glacial Till	0.20-21.39	Firm to stiff brown slightly sandy gravelly CLAY with medium cobble content and low boulder content.

9.7.33 No karstic features were noted within the scheme boundary.

Encountered groundwater conditions

9.7.34 Groundwater was observed in a number of exploratory holes with a response zone depth range of 0.80 to 17.00m below ground level (bgl). Water strikes generally limited to granular materials and weathered rock/rockhead interface and standing water levels were encountered. Details are presented on the borehole logs in GIR Package B-M6 Junction 40 to Kemplay Bank and Penrith to Temple Sowerby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

GI chemical testing overview

9.7.35 Geo-environmental testing of Made Ground and natural strata that has been carried out within the M6 Junction 40 to Kemplay Bank study area. Full details are given in GIR Package B-M6 Junction 40 to Kemplay Bank and Penrith to Temple Sowerby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4) and key findings are summarised below.

9.7.36 Groundwater and surface water samples were also collected for analysis.

9.7.37 Visual and olfactory evidence of contamination during the ground investigation predominantly comprised a hydrocarbon odour and gravels of asphalt and bitumen observed in only one exploratory location, at Junction 40, 44m west of Depot (SD M6J40.005a at 3.55m bgl) and fragments of asphalt and slag with a hydrocarbon odour observed in four GI locations at Kemplay Bank.

9.7.38 A summary of the GI sampling and analysis along with the findings of preliminary assessment are presented in Table 9-13: Summary of chemical analysis of Kemplay Bank Roundabout samples below.

Table 9-12: Summary of chemical analysis of the M6 Junction samples

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
Soil	37 (comprising 6 from Topsoil, 20 from Made Ground, and 11 from natural superficial deposits)	Primary metals and metalloids, secondary metals and metalloids, inorganics, Cyanide/Phenol analysis, Total Petroleum Hydrocarbon Criteria Working Group (TPH CWG), speciated polycyclic aromatic hydrocarbons (PAHs), semi-volatile organic compounds (SVOCs) and volatile organic compounds (VOCs) testing.	TPH Aromatic C12-C26, TPH Aromatic C16–C21, and TPH Aromatic C21-C35 were recorded as exceeding the Public Open Space Park (POSPark) assessment criteria.	SD M6J40.005a Made Ground with strong hydrocarbon odour sampled at 3.55 m bgl (located at Junction 40, 44m west of Depot)	Exceedances likely to be associated with bitumen and asphalt gravels identified as present in the soil.
Soils - Asbestos	28 (comprising Topsoil, Made Ground, and natural superficial deposits)	Asbestos (presence and identification and quantification)	No asbestos was detected within samples examined in the laboratory. No asbestos containing materials were observed during ground investigation.	-	-
Soils - Leachate	14 (comprising Topsoil, Made Ground, and natural superficial deposits)	pH, electrical conductivity, total dissolved solids, chloride, fluoride, sulphate, DOC, metals, phenols	pH, copper, lead, molybdenum and zinc were recorded as exceedances screened against Controlled Waters Risk Assessment (CWRA) using the lowest available Water Quality Standards (WQS) (i.e., Drinking Water Standards (DWS) or Environmental Quality Standard	BH M6J40.002 Topsoil-slightly sandy very gravelly clay sampled at 0.50m bgl (between A592 and A66, north of Junction 40)-pH and lead. BH M6J40.001 Made Ground Topsoil-sandy clay sampled at 0.50m bgl (between A592 and A66,	Leachate testing identified exceedances of lead which is speculated to be as a result of naturally elevated background levels resulting from regional bedrock mineralisation.

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
			(EQS) of Tier 1 and 2 (14 samples). Soil leachate tests do not simulate in-situ conditions and concentrations from soil leachate tests are considered conservative. Therefore, these were progressed to Tier 2 assessment. Exceedances of Tier 2 criteria for pH (1 sample) and lead (5 samples)	north of Junction 40), HTP M6J40.001 Gravelly sandy clay sampled at 1.00m bgl, HTP M6J40.002 Topsoil-gravelly sandy clay sampled at 0.30m bgl (both located 9m north of A66 after Junction 40), and TP M6J40.007 Made Ground-rare brick sampled at 0.15m bgl (located off A592 road, north of A66, 36m close to Environment Agency and Forestry Commission building)-lead.	
Groundwater	1 (BH M6J40.001 at depth range 0f 0.80-5.00m bgl between A592 and A66, north of Junction 40).	Metals and metalloids, secondary metals and metalloids, major ions, ammoniacal nitrogen, electrical conductivity, total suspended solids, oxygen demand, Total Petroleum Hydrocarbon Criteria Working Group (TPH CWG), Speciated PAHs.	No exceedances were recorded of the against Controlled Waters Risk Assessment (CWRA) using the lowest available Water Quality Standards (WQS) (i.e., Drinking Water Standards (DWS) or Environmental Quality Standard (EQS) of Tier 1 and Tier 2. .	-	-
Surface water		-	No surface waters are located in close proximity to the scheme (adjacent and/or <50m).	-	-

Table 9-13: Summary of chemical analysis of Kemplay Bank Roundabout samples

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
Soil	45 (comprising 6 from Topsoil, 23 from Made Ground, and 16 from natural superficial deposits)	Primary metals and metalloids, secondary metals and metalloids, inorganics, CN/Phenol analysis, TPH CWG, speciated PAHs, SVOCs and VOCs testing.	No samples were recorded as exceeding the POSPark assessment criteria	-	-
Soils - Asbestos	32 (comprising Topsoil, Made Ground, and natural superficial deposits)	Asbestos (presence and identification and quantification)	No asbestos was detected within samples examined in the laboratory. No asbestos containing materials were observed during ground investigation.	-	-
Soils - Leachate	18 (comprising Topsoil, Made Ground, and natural superficial deposits)	pH, electrical conductivity, total dissolved solids, chloride, fluoride, sulphate, DOC, metals, phenols	pH, arsenic, cadmium, copper, lead, manganese, molybdenum, nickel and zinc were recorded as exceedances screened against CWRA using the lowest available WQS (i.e., DWS or EQS) of Tier 1 and 2 (18 samples) Soil leachate tests do not simulate in-situ conditions and concentrations from soil leachate tests are considered conservative.	BH KBR005 Made Ground sampled at 0.60m bgl (inside the Kemplay Bank Roundabout, 11m from the east of A6 road)- nickel. TP KBR006 Gravel sampled at 1.20m bgl (located south of Kemplay Bank Roundabout, 20m east of New Penrith Fire and Ambulance Station), BH KBR002 very sandy clayey gravel sampled at 0.50m bgl (located 182 m from the Kemplay Bank Roundabout north of A66), and SD KBR007	Leachate testing identified exceedances of lead which is speculated to be as a result of naturally elevated background levels resulting from regional bedrock mineralisation.

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
			Therefore, these were progressed to Tier 2 assessment. Exceedances of Tier 2 criteria for pH (3 sample), arsenic (1 sample), nickel (1 sample), and lead (7 samples)	Made Ground sampled at 0.50m bgl (inside the Kemplay Bank Roundabout, 34m north of A66)-lead TP KBR009 Made Ground-gravelly very clayey sand sampled at 1.20m bgl (located 54m south of A66 near Carleton Hall)-arsenic and lead. TP KBR003 Topsoil-gravelly slightly clayey sand sampled at 0.30m bgl (located 158m south of A66 nearest to Farm-Happy Horse Riding Centre), BH KBR003 Topsoil sampled at 0.30m bgl (located 32m east of Kemplay Bank Roundabout), and BH KBR011 Topsoil-slightly gravelly clayey silty sand sampled at 0.30m bgl (off A6 road, 31m south of New Penrith Fire and Ambulance Station) - pH and lead.	
Groundwater	3	Metals and metalloids, secondary metals and metalloids, major ions, ammoniacal nitrogen, electrical conductivity, total suspended solids, oxygen demand, TPH	Exceedances of the Tier 1 groundwater criteria for acenaphthene, fluorene, and phenanthrene (1 sample). Therefore, these were progressed to Tier 2 assessment.	BH KBR012 sampled at 3.00-15.50m bgl (located 10m south of A66 near Carleton Hall) - acenaphthene, fluorene, and phenanthrene	Recorded exceedances for acenaphthene and TPH CWG

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
		CWG, Speciated PAHs.	Exceedances of Tier 2 criteria for acenaphthene and TPH CWG-Aromatic >C12-C16.	BH KBR012 sampled at 3.00-15.50m bgl (located 10m south of A66 near Carleton Hall)- acenaphthene and TPH CWG-Aromatic >C12-C16	
Surface water		-	No surface waters are located in close proximity to the scheme (adjacent and/or <50m).	-	-

Ground gas

9.7.39 A field monitoring was undertaken between 27 May 2021 and 22 June 2021 as part of the GI. The recorded methane concentrations were between 0.0 and 0.6 % volume. Carbon dioxide concentrations between 0.0 and 7.8 % volume, only exceeding the 5 % Action Level on two occasions (BH M6J40.001 between A592 and A66, north of Junction 40 and SD KBR007 inside the Kemplay Bank Roundabout, 34m north of A66). Oxygen levels were between 5.7 and 21.3 % with very low flow rates recorded (0.0-1.0 l/h).

Summary

9.7.40 The human health and controlled waters risk assessments, carried out and detailed in GIR Package B (ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4)), indicates there is low risk from land affected by contamination within M6 Junction 40 to Kemplay Bank area. The chemical results and subsequent quantitative risk assessment showed that there is low risk to human health receptors within the scheme. The controlled waters risk assessment indicates a number of exceedances of Tier 1 and Tier 2, presenting a low risk to controlled waters. No surface waters are located within a close proximity of the scheme. Overall, recorded exceedances within the study area were not located within zone 1 of the route alignment.

Soils

9.7.41 Published soils mapping shows 'Newbiggin Association' and 'Wick 1 Association' soils to be present. These are typically well to moderately well drained fine loamy to coarse loamy soils with some rock at depth. They fall into Wetness Class (WC) 1 or 2 and into ALC Grade 3a in the study area.

9.7.42 The survey from the M6 Junction 40 to Kemplay Bank was carried out between 7 and 28 February 2022 and comprised 23 number of survey locations. Access was not granted for survey of a further 6 number locations within the study area due to livestock in the fields at the time. A sufficient number of sample locations were accessed to enable a land classification value.

9.7.43 To the west of the M6 Junction soils with 30-40cm brown or dark brown medium clay loam topsoil over similarly coloured mainly medium or heavy clay loam subsoil sometimes moderately stony below 40-70cm were found. The soils are well drained showing no greyish or pale colours or ochreous mottling.

9.7.44 In the centre of this scheme soils with 25-35cm brown or dark brown sandy clay loam topsoil over similarly coloured sandy clay loam subsoil sometimes moderately stony below 28-60cm were found. The soils are well drained showing no greyish or pale colours or ochreous mottling.

9.7.45 On the east of the scheme soils with variable topsoil as well as variable subsoil texture were found. The topsoil textures identified were dark brown medium sandy loam, coarse sandy loam, sandy clay loam or

medium clay loam topsoil over dark brown or brown medium sandy loam, medium clay loam or sandy clay loam upper subsoil over similarly coloured loamy sand, medium sand, coarse sand or coarse sandy loam subsoil. The soils are well drained showing no greyish or pale colours or ochreous mottling except for some ochreous mottling evident in one profile.

9.7.46 The land in the west of the scheme is limited to Subgrade 3a and in the remainder of the scheme to Grade 2 by climatic limitations. The soil grades, distribution across the scheme and receptor value (sensitivity) are summarised in Table 9-14: Soil resources - M6 Junction 40 to Kemplay Bank.

Table 9-14: Soil resources - M6 Junction 40 to Kemplay Bank

Soil grades present within the Order Limits	Permanent land take within the Order Limits	Temporary land take within the Order Limits	Total area of each grade within Order Limits	DMRB LA 109[1] Receptor Value (Sensitivity)
Grade 1	n/a	n/a	None identified	n/a
Grade 2	4.7ha	5.6ha	10.3ha (21%)	Very High
Grade 3 subgrade 3a	1.0ha	1.6ha	2.6ha (5%)	High
Grade 3 subgrade 3b	n/a	n/a	None identified	n/a
Grade 4	n/a	n/a	None identified	n/a
Grade 5	n/a	n/a	None identified	n/a
Non-agricultural	1.5ha	0.1ha	1.8ha (3%)	Negligible
Urban	26.3ha	3.6ha	29.9ha 61%)	Negligible
Not surveyed	2.6ha	1.9ha	4.5ha (14%)	n/a

9.7.47 The ALC survey recorded <30% of the area surveyed is formed of soil of Agricultural Land Classification Grades 2 and 3a (BMV land) in the M6 Junction 40 to Kemplay Bank scheme Order Limits. 5.7ha of the Grades 2 and 3a will be within permanent land take. Approximately 7ha of Grades 2 and 3a will be within the area required for temporary construction land take.

Penrith to Temple Sowerby

Geological context

9.7.48 The Penrith to Temple Sowerby scheme is indicated to be underlain by Made Ground, followed by natural superficial deposits comprising Glacial Till, Glaciofluvial Deposits, River Terrace Deposits and Alluvium. Glacial meltwater channels and drumlin features are present.

Geodiversity sites

9.7.49 No geodiversity sites have been identified in the study area.

Contamination sources

9.7.50 Potentially contaminative sites have been identified which could be impacted by the Project. These include farms, a historical tank and a sewage works, see ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). The potential contaminated sites for this scheme are prefixed CL03- in the appendix.

Contamination receptors

9.7.51 A number of potential receptors to contamination have been identified in the study area. Further details are provided in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). These include residents of nearby properties, principal aquifer and source protection zone and surface water bodies including the River Lowther and River Eamont. Further information on groundwater and surface water receptors is provided in ES Chapter 14: Road Drainage and the Water Environment.

9.7.52 There are two designated ecological receptors within the study area, the River Eden SAC and the River Eden Tributaries SSSI, 60m and 80m north-west of the scheme, respectively. Further detail on these statutory designated sites, and their qualifying habitats and vegetative communities, is provided in Chapter 6: Biodiversity.

Ground investigation

9.7.53 A programme of ground investigation took place between 15 February 2021 and 28 April 2021. Key findings relevant to this chapter are presented below. The full details of the ground investigation and findings are reported in GIR Package B-M6 Junction 40 to Kemplay Bank and Penrith to Temple Sowerby in ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

Encountered ground conditions

9.7.54 A summary of the encountered ground conditions based on a review of the recent exploratory holes within the study area is provided in Table 9-15: Summary of proven geology and ground conditions: Penrith to Temple Sowerby. Glacial meltwater channels and drumlin features are present in the Penrith to Temple Sowerby area, and is identified below as Fluvio-glacial materials. The fluvio-glacial tills (FG) tend to be mainly granular materials, comprising sands, gravels, cobbles and boulders. The fine material tends to have been washed out in the meltwater, although up to 10% fine material may still be present.

Table 9-15: Summary of proven geology and ground conditions: Penrith to Temple Sowerby

Strata	Proven depth range (m bgl)	Description
Superficial		
Topsoil	0.00-1.20	Sandy gravelly CLAY or a SAND with rootlets.
Made Ground-Cohesive	0.00-3.55	Stiff dark brown sandy gravelly CLAY with low cobble content.
Made Ground-Granular	0.00-3.65	Dark brown slightly gravelly fine to coarse SAND with occasional roots and rootlets.
Granular Glacial Till	0.20-13.95	Clayey gravelly SAND and less often as clayey sandy GRAVEL
Fluvioglacial Till	0.25-25.67	Dense brown clayey gravelly fine to coarse SAND with low cobble content.
Cohesive Glacial Till-Sandy	0.10-25.73	Gravelly clayey SAND or gravelly sandy CLAY.
Cohesive Glacial Till	0.20-21.39	Firm to stiff brown slightly sandy gravelly CLAY with medium cobble content and low boulder content.
Sand	0.65-9.24	Extremely weak reddish-brown SANDSTONE recovered as gravelly sand. (Possible Weathered Bedrock).
Alluvium	0.40-3.90	Blackish brown fibrous Peat with plant remains, rare gravel and pockets of soft to firm gravelly clay.
Bedrock		
Penrith Sandstone Formation	4.10-15.25	Weak locally medium strong partially unweathered thinly laminated reddish brown fine to coarse SANDSTONE.

9.7.55 No karstic features were noted within the scheme boundary.

Encountered groundwater conditions

9.7.56 Groundwater was observed in a number of exploratory holes with a response zone depth range of 1.00 to 15.50m bgl. Water strikes generally limited to granular materials and weathered rock/rockhead interface and standing water levels were encountered. Details are presented on the borehole logs in GIR Package B-M6 Junction 40 to Kemplay Bank and Penrith to Temple Sowerby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

GI chemical testing overview

9.7.57 Geo-environmental testing of Made Ground and natural strata that has been carried out within the Penrith to Temple Sowerby study area. Full details are given in GIR Package B-M6 Junction 40 to Kemplay Bank and Penrith to Temple Sowerby ES Appendix 9.2: Ground Investigation

Reports (Application Document 3.4) and key findings are summarised below.

9.7.58 Groundwater and surface water samples were also collected for analysis.

9.7.59 Visual and olfactory evidence of contamination during the ground investigation predominantly comprised ballast gravels observed in two locations (BH PTS001A located 37m south of A66 between Flagstaff Rifle Range to the north and Farm-Fremington Lodge to the south and BH PTS023 located 5m north of A66 near Whinfell House Farm to the south) and black asphalt gravel with a strong tar odour (BH PTS001A).

9.7.60 Table 9-16: Summary of chemical analysis of Penrith to Temple Sowerby scheme samples presents a summary of the GI sampling, analysis along with the findings of preliminary assessment.

Table 9-16: Summary of chemical analysis of Penrith to Temple Sowerby scheme samples

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
Soil	93 (comprising 21 from Topsoil, 18 from Made Ground, and 53 from natural superficial deposits)	Primary metals and metalloids, secondary metals and metalloids, inorganics, CN/Phenol analysis, TPH CWG, speciated PAHs, SVOCs and VOCs testing.	Benzo(a) anthracene, chrysene, benzo(b) fluoranthene, benzo(a) pyrene, indeno(1,2,3-cd) pyrene, dibenzo(a,h) anthracene were recorded as exceeding the POSPark assessment criteria (2 samples of natural strata).	BH PTS023 Made Ground-Ballast-sandy gravel sampled at 0.50m bgl (located 5m north of A66 near Whinfell House Farm to the south)- benzo(b) fluoranthene, and dibenzo(a,h) anthracene. BH PTS001A Slightly clayey slightly gravelly sand sampled at 0.40m bgl (located 37m south of A66 between Flagstaff Rifle Range to the north and Farm-Fremington Lodge to the south)- benzo(a) anthracene, chrysene, benzo(b) fluoranthene, benzo(a) pyrene, indeno(1,2,3-cd) pyrene, dibenzo(a,h) anthracene. (Ballast gravels noted in both locations in addition to the recorded asphalt gravel in the strata above in BH PTS001A).	Very high exceedances for PAHs located in BH PTS001A which recorded asphalt gravels in the strata above and ballast gravels were noted in both locations. The primary exposure pathway for PAH is via direct contact.
Soils - Asbestos	40 (comprising Topsoil, Made Ground, and natural superficial deposits)	Asbestos (presence and identification and quantification)	Chrysotile asbestos cement (<0.001 %) detected within a sample examined in the laboratory (1 sample).	BH PTS001A Slightly clayey slightly gravelly sand sampled at 0.40m bgl (located 37m south of A66 between Flagstaff Rifle Range to the north and Farm-Fremington Lodge to the south)- chrysotile asbestos cement	Apart from the affected laboratory sample, no asbestos containing materials were observed during ground investigation
Soils - Leachate	39 (comprising Topsoil, Made	pH, electrical conductivity, total dissolved solids, chloride, fluoride,	pH, arsenic, copper, lead, molybdenum, and zinc exceedances (38 samples).	BH PTS022 possible Made Ground-slightly clayey slightly gravelly sand sampled at 0.20m bgl (located 10m south of A66 near	Leachate testing identified exceedances of arsenic and lead which are speculated to

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
	Ground, and natural superficial deposits)	sulphate, DOC, metals, phenols	6 samples were located 50m or less from a surface water and therefore have been conservatively screened against CWRA using the lowest available WQS (i.e., DWS or EQS) of Tier 1 and 2 and are unable to progress to T2 WQS evaluation. The remaining samples were progressed to Tier 2 assessment. Exceedances of Tier 2 criteria for pH (24 sample), arsenic (2 sample), lead (11 sample)	Whinfell House Farm)-pH, copper, lead, and zinc. BH PTS005 Peat sampled at 1.20m bgl (located 20m south of A66 near Lightwater Smithy to the west) and BH PTS007 Soft light brown gravelly sandy clayey silt sampled at 0.50m bgl (located 20m north of A66 near River Eamont to the north)-pH, copper, and lead. BH PTS011 Slightly gravelly sandy clay sampled at 1.20m bgl (located 15m south of A66 near Whinfell Park Cottages farm to the south)-pH, copper, and zinc. BH PTS008 Made Ground-ashy sandy gravel with concrete and limestone sampled at 0.20m bgl (located 26m south of A66 near Whinfell Park Cottages farm to the south-west)-copper, and molybdenum. BH PTS023 Made Ground-Ballast-sandy gravel sampled at 0.50m bgl (located 5m north of A66 near Whinfell House Farm to the south)-copper, lead, and zinc (not progressed to Tier 2 WQS evaluation). BH PTS018 Dense brown sand sampled at 0.60m bgl (located 21m north of A66) and TP PTS003 Made Ground-clayey gravelly sand with general waste materials and rebar sampled at 0.20m bgl (located 19m north of A66 near Farm-Brougham Castle Lodge to the east)-arsenic and lead. BH PTS012 Topsoil-rapeseed crop overlying slightly gravelly clayey sand sampled at	be as a result of naturally elevated background levels resulting from regional bedrock mineralisation.

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
				0.30m bgl (located 19m north of A66), TP PTS006 Slightly clayey slightly gravelly sand sampled at 0.20m bgl (located 48m south of A66 near Lightwater Smithy to the west), TP PTS007 Slightly clayey gravelly sand sampled at 0.50m bgl (located 37m north of A66 near Lightwater Smithy to the west), TP PTS020 Reworked Topsoil sampled at 0.10m bgl (located 14m south of A66 near high Barn Farm to the east), TP PTS021 Topsoil-gravelly clayey sand sampled at 0.20m bgl (located 16m north of A66 near high Barn Farm to the east), TP PTS024 Slightly gravelly clayey sand sampled at 0.60m bgl (located 30m north of A66), TP PTS025 Reworked Topsoil sampled at 0.20m bgl (located 21m south of A66), and TP PTS027 Made Ground-Brown slightly gravelly clayey fine to coarse sand sampled at 0.50m bgl (located 11m south of A66 near Whinfell House Farm to the east)-pH and lead. TP PTS022 Made Ground-Grass over brown slightly gravelly clayey fine to coarse sand sampled at 0.10m bgl (located 13m south of A66)-lead. BH PTS006 Topsoil-Slightly clayey silty sand sampled at 0.20m bgl (located 31m north of A66 near Lightwater Smithy to the east), BH PTS010 Topsoil sampled at 0.30m bgl (located 35m north of A66 near Whinfell Park	

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
				Cottages Farm to the south), BH PTS013 Reddish brown slightly gravelly clayey fine to coarse sand sampled at 1.00m bgl (located 19m north of A66 near Whinfell Park Cottages Farm to the south-east), BH PTS014 Orangish brown slightly gravelly slightly silty fine to coarse sand sampled at 0.60m bgl (located 20m north of A66 near Farm outbuilding to the north), BH PTS017 Reddish brown gravelly clayey sand sampled at 0.40m bgl (located 15m south of A66 near High Barn Farm to the west), BH PTS019 Brown slightly gravelly sand sampled at 0.50m bgl (located 30m south of A66 near High Barn Farm to west), BH PTS020 Slightly gravelly slightly clayey sand sampled at 0.50m bgl (located 23m north of A66), BH PTS021 sampled at 0.50m bgl (located 24m north of A66), BH PTS022 possible Made Ground-slightly clayey slightly gravelly sand sampled at 0.20m bgl (located 10m south of A66 near Whinfell House Farm), TP PTS009 Slightly clayey gravelly sand sampled at 0.50m bgl (located 41m north of A66), TP PTS010 Clayey sandy gravel sampled at 1.35m bgl (located 77m north of A66), TP PTS013 Topsoil-clayey slightly gravelly sand sampled at 0.20m bgl (located 58m north of A66),	

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
				TP PTS014 Slightly gravelly clayey sand sampled at 2.00m bgl (located 26m north of A66), TP PTS015 Reddish brown slightly gravelly clayey fine to coarse sand sampled at 1.80m bgl (located 12m south of A66), TP PTS017 Reddish brown slightly gravelly clayey fine to coarse sand sampled at 1.80m bgl (located 84m south of A66) and TP PTS026 Gravelly clayey sand sampled at 0.60m bgl (located 28m north of A66 near Whinfell House Farm to the south)-pH (Tier 2 exceedances).	
Groundwater	6	Metals and metalloids, secondary metals and metalloids, major ions, ammoniacal nitrogen, electrical conductivity, total suspended solids, oxygen demand, TPH CWG, Speciated PAHs.	Exceedances of the Tier 1 groundwater criteria for ammoniacal nitrogen, and TPH fractions (3 sample). 1 sample was located 50m or less from a surface water and therefore has been conservatively screened against both DWS and WQS and is unable to progress to T2 WQS evaluation. Therefore, these were progressed to Tier 2 assessment. Exceedance of Tier 2 criteria for TPH CWG-Aromatic	BH PTS011 sampled at 8.00m bgl (located 15m south of A66 near Whinfell Park Cottages farm)-copper (not progressed to Tier 2 WQS evaluation). BH PTS003 sampled at 8.00m bgl (located 5m north of A66)-TPH CWG-Aromatic >C12-C16 and Aromatic>C16-C21	The exceedances concentrations recorded are unlikely to pose a significant risk as no corresponding detectable concentration was recorded within the soil (solid) samples from those locations. Exceedances may be attributed to off-site sources

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
			>C12-C16, and Aromatic>C16-C21 (1 sample)		
Surface water (unnamed tributary of River Greta)	2	Metals and metalloids, secondary metals and metalloids, major ions, ammoniacal nitrogen, electrical conductivity, total suspended solids, oxygen demand, TPH CWG, Speciated PAHs, Phenols and Cyanides	Exceedances of the Tier 1 surface water criteria for ammoniacal nitrogen, arsenic, copper, lead, zinc, and TPH fractions (2 samples). Therefore, these were progressed to Tier 2 assessment. Exceedances of Tier 2 criteria for copper, zinc and Aliphatic >C8-C10, Aliphatic >C10-C12, Aromatic >C10-C12, Aromatic >C16-C21, and Aromatic >C21-C35	SW BH PTS011- copper, zinc and Aliphatic >C8-C10, Aliphatic >C10-C12, Aromatic >C10-C12, Aromatic >C16-C21, and Aromatic >C21-C35	Recorded marginal exceedance for copper and lead. Exceedances for TPH fractions recorded.

Ground gas

9.7.61 A field monitoring was undertaken between 26 May 2021 and 23 June 2021 as part of the GI. The recorded carbon dioxide concentrations ranged between 0.0 and 4.1 % volume; none exceeded the 5 % Action Level. Oxygen levels were between 4.6 and 21.0 %. Methane was not detected in any of the boreholes during the survey and very low flow rates were recorded (0.0-0.2 l/h).

Summary

9.7.62 The human health and controlled waters risk assessments, carried out and detailed in GIR Package B (ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4), indicates there is low risk from land affected by contamination within the Penrith to Temple Sowerby area. The chemical results and subsequent quantitative risk assessment showed that there is low risk to human health receptors within the scheme. The controlled waters risk assessment indicates a number of exceedances of Tier 1 and Tier 2, unlikely to present significant risk as no corresponding detectable concentration was recorded within soil samples from those locations. A low risk is also presented from surface water marginal exceedances. Overall, recorded exceedances within the study area were not located within zone 1 of the route alignment.

Soils

9.7.63 Published soil mapping shows Newport 1 Association soils to be present. They are typically well drained deep sandy and coarse loamy soils and in this part of the country fall predominantly into WC 1 (ALC Grade 2) but contain 10% of subordinate soils (i.e., Blackwood) which, where drained fall into WC 1 and where undrained fall into WC 3 and 4 (ALC Grade 3a/b).

9.7.64 Wick 1 Association soils are mapped in the north western corner of the study area. the soil type is. This soil type is typically a well to moderately well drained, coarse loam and falls into WC 1 or 2 and ALC Grade 2.

9.7.65 The soil survey from Penrith to Temple Sowerby was carried out between 9 and 15 February 2022 and comprised 112 number survey locations. A further six locations were surveyed on 15 March 2022. Access was not granted for survey for 18 number locations due to livestock in the fields at the time. A sufficient number of sample locations were accessed to enable a land classification value.

9.7.66 The soils predominantly have medium sandy loam and occasionally loamy sand or sandy clay loam topsoil which are dark brown in colour and 20-40cm deep. The subsoil texture is predominantly medium sand or medium loamy sand (particularly the upper subsoil). The subsoil colour is predominantly brown and subsoil depth extended to 120cm plus deep; because of their sandy texture the soils are well drained. The exception is when top and subsoil are sandy clay loam in texture and drainage is imperfect. The topsoil and subsoil are occasionally very slightly stone with the lower subsoil, also occasionally, being moderately stony.

9.7.67 The land in the scheme is predominantly Grade 2 because of an overall climatic limitation. Small areas are Subgrade 3a because of a droughtiness limitation where the topsoil is loamy sand and the soil profile has a significant stone content which reduces available water capacity, or there is a wetness limitation due to the topsoil and subsoil being sandy clay loam in texture. The soil grades distribution across the scheme and receptor value (sensitivity) are summarised in Table 9-17: Soil resources: Penrith to Temple SowerbyTable 9-12: Summary of chemical analysis of the M6 Junction samples.

Table 9-17: Soil resources: Penrith to Temple Sowerby

Soil grades present within the Order Limits	Permanent land take within the Order Limits	Temporary land take within the Order Limits	Total area of each grade within Order Limits	DMRB LA 109[1] Receptor Value (Sensitivity)
Grade 1	n/a	n/a	None identified	n/a
Grade 2	30.5ha	34.8ha	65.3ha (61%)	Very High
Grade 3 subgrade 3a	4.2ha	2.5ha	6.7ha (7%)	High
Grade 3 subgrade 3b	n/a	n/a	None identified	n/a
Grade 4	n/a	n/a	None identified	n/a
Grade 5	n/a	n/a	None identified	n/a
Non-agricultural	1.1ha	1ha	2.1ha (2%)	Negligible
Urban	21.1ha	<0.1ha	21.7ha (20%)	Negligible
Not surveyed	6.5ha	4.3ha	10.8ha (10%)	n/a

9.7.68 The ALC survey recorded approximately 70% of the area surveyed is formed of soil of Agricultural Land Classification Grades 2 and 3a (BMV land) within the Penrith to Temple Sowerby Order Limits. Approximately 35 ha of the Grades 2 and 3a soils will be within permanent land take. Approximately 37 ha of Grades 2 and 3a soils will be within the area required temporary construction land take.

Temple Sowerby to Appleby

Geological context

9.7.69 Temple Sowerby to Appleby scheme is underlain by Made Ground, above natural superficial deposits comprising Glacial Till, Alluvium and Peat. The published bedrock below the scheme comprises the Penrith Sandstone Formation and Eden Shale Formation.

9.7.70 Four seams of gypsum and anhydrite are present in the Eden Shale Formation sequence. Mining is restricted to the highest-grade section of the lowest, thickest seam – 'A-bed'. The A-bed seam is up to 30 metres thick and is a series of alternating gypsum and gypsiferous shale beds, however the mining horizon is typically 7m thick at Longriggs Mine. The highest-grade sections contain secondary satin spar gypsum bands. Historically B-bed gypsum seam has also been extensively mined.

Geodiversity sites

9.7.71 No geodiversity sites have been identified in the study area.

Contamination sources

9.7.72 Potentially contaminative sites have been identified which could be impacted by the Project, including farms, dismantled railway, infilled ground, a garage/haulage yard, petrol filling station and British gypsum tip, as detailed in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). The potential contaminated sites for this scheme are prefixed CL04- and CL05- in the appendix.

Contamination receptors/

9.7.73 A number of potential receptors to contamination have been identified in the study area. These include the residents of nearby properties, a principal groundwater aquifer and surface watercourses including Trout Beck, as detailed in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). Further information on groundwater and surface water receptors is provided in ES Chapter 14: Road Drainage and the Water Environment.

9.7.74 Trout Beck is part of River Eden SAC. Further detail on these statutory designated sites, and their qualifying habitats and vegetative communities, is provided in Chapter 6: Biodiversity.

Ground investigation

9.7.75 A programme of ground investigation took place between 15 February 2021 and 28 April 2021 and comprised 76 cable percussion boreholes to a maximum depth of 12.45m, 20 cable percussion boreholes extended by rotary coring to a maximum depth of 40.55m, one hand excavated inspection pit to a maximum depth of 0.90m, one dynamic sample borehole with rotary-follow on rotary coring to a maximum depth of 42.50m, 99 machine dug trial pits to a maximum depth of 3.80m, and three window sample boreholes to a maximum depth of 4.45m. Key findings relevant to this chapter are presented below. The full details of the ground investigation and findings are reported in *GIR Package A-Temple Sowerby to Appleby and Appleby to Brough* ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

Encountered ground conditions

9.7.76 A summary of the encountered ground conditions based on ground investigation within the study area is provided in Table 9-18: Summary of proven geology and ground conditions: Temple Sowerby to Appleby.

Table 9-18: Summary of proven geology and ground conditions: Temple Sowerby to Appleby

Strata	Proven depth range (mbgl)	Description
Superficial		
Made Ground Cohesive	-	Not encountered

Strata	Proven depth range (mbgl)	Description
Made Ground Granular	0.00-0.40	Typically associated with obvious man-made materials either from this source or from coarse till.
Granular Glacial Till	0.00-13.10	Clayey gravelly SAND and less often as clayey sandy GRAVEL
Fluvioglacial Till	0.30-8.00	Clayey or silty sandy GRAVEL
Cohesive Glacial Till-Sandy	0.00-10.45	Gravelly clayey SAND or gravelly sandy CLAY
Cohesive Glacial Till	0.00-16.20	Slightly gravelly sand CLAY, with a variable cobble content.
Sand	0.10-14.00	Slightly gravelly clayey fine to coarse sand.
Bedrock		
Penrith Sandstone	2.00-42.00	Very weak or extremely weak on the basis of its cores.

9.7.77 Karstic features have been identified in the vicinity of Kirkby Thore in both the Penrith Sandstone Formation and Eden Shales Formation. The karst features are identified as depressions in the land surface at Kirkby Thore where the Penrith Sandstone Formation is overlain by the Eden Shales Formation. Within the Eden Shales Formation are several gypsum beds, which tend to be angular and elongate in form, and generally overlie the mapped gypsum units. The shallow nature of the gypsum deposits indicates a significant karst risk where the road crosses these unit. It is considered to be a high karst risk as a result of the high solubility of gypsum and due to the faulted contact between the Eden Shales and the Penrith Sandstone as shown in ES Appendix 14.8: Desk Study Karst Risk Assessment (Application Document 3.4).

Encountered groundwater conditions

9.7.78 Groundwater was observed in a number of exploratory holes with a response zone depth range of 1.00 to 11.50m bgl. Water strikes generally limited to granular materials and weathered rock/rockhead interface and standing water levels were encountered. Details are presented on the borehole logs in GIR Package A-Temple Sowerby to Appleby and Appleby to Brough ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

GI chemical testing overview

9.7.79 Geo-environmental testing of Made Ground and natural strata has been carried out within the Temple Sowerby to Appleby study area. Full details of which are given in the *GIR Package A- Temple Sowerby to Appleby and Appleby to Brough* ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4), key findings are summarised below.

9.7.80 Groundwater and surface water samples were also collected for analysis.

9.7.81 The majority of the exploratory locations between Temple Sowerby to Appleby recorded no visual or olfactory evidence of contamination on the borehole or trial pit logs. However, visual and olfactory evidence of contamination around the Crackenthorpe area where some coal fragments were observed in shallow superficial deposits.

9.7.82 A summary of the GI sampling and analysis along are presented in Table 9-19: Summary of chemical analysis of Temple Sowerby to Appleby samples.

Table 9-19: Summary of chemical analysis of Temple Sowerby to Appleby samples

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
Soil	83 (comprising 20 from Topsoil, 19 from Made Ground, and 44 from natural superficial deposits)	Primary metals and metalloids, secondary metals and metalloids, inorganics, CN/Phenol analysis, TPH CWG, speciated PAHs, SVOCs and VOCs testing.	No samples were recorded as exceeding the POSPark assessment criteria.	-	-
Soils - Asbestos	42 (comprising Topsoil, Made Ground, and natural superficial deposits)	Asbestos (presence and identification and quantification)	No asbestos was detected within samples examined in the laboratory. No asbestos containing materials were observed during ground investigation.	-	-
Soils - Leachate	29 (comprising Topsoil, Made Ground, and natural superficial deposits)	pH, electrical conductivity, total dissolved solids, chloride, fluoride, sulphate, DOC, metals, phenols	pH, copper, lead, molybdenum and zinc were recorded as exceedances screened against CWRA using the lowest available WQS (i.e., DWS or EQS) of Tier 1 and 2 (23 samples). Soil leachate tests do not simulate in-situ conditions and concentrations from soil leachate tests are considered conservative.	TP KTA002 Topsoil sampled at 0.20m bgl (located 336m north of A66 near Dismantled railway to the south), TP KTA012 Brown clayey sand sampled at 0.40m bgl (located 975m to the north of A66), TP KTA016 Made Ground-soft orangish brown sandy slightly gravelly clay sampled at 0.50m bgl (located 450m north of A66), TP KTA018 Firm to stiff high strength reddish brown with localised yellow mottling slightly sandy gravelly clay sampled at 1.10m bgl (located 79m north of A66), TP KTA019 Firm to stiff high strength reddish brown with localised yellow mottling slightly sandy gravelly clay sampled at 1.20m	Leachate testing identified minor exceedances of lead which is naturally likely to be lower – this is confirmed by the absence of lead in groundwater samples from the same locations (e.g., BH KT018, and BH KTA021.

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
			Therefore, these were progressed to Tier 2 assessment. Minor exceedances of Tier 2 criteria for lead (8 samples)	bgl (located 74m north of A66 near Dismantled railway to the south), BH KTA004 Clay sampled at 0.50m bgl (located 282m north of A66 near Dismantled railway to the south), BH KTA008 Topsoil sampled at 0.20m bgl (located 700m north of A66 near Dismantled railway to the south), and BH KTA014 Topsoil sampled at 0.20m bgl (located 714m north of A66 near Dismantled railway to the south).	
Groundwater	4	Metals and metalloids, secondary metals and metalloids, major ions, ammoniacal nitrogen, electrical conductivity, total suspended solids, oxygen demand, TPH CWG, Speciated PAHs.	Exceedances of the Tier 1 groundwater criteria for ammoniacal nitrogen, copper, lead, molybdenum, sodium, zinc, toluene and several TPH. Therefore, these were progressed to Tier 2 assessment. Exceedances of Tier 2 criteria for ammoniacal nitrogen, sulphate, sodium, and TPH CWG.	BH KTA015 sampled at 6.00m bgl (located 656m north of A66), and BH KTA022 sampled at 5.50m bgl (located 45m north of A66 near Dismantled railway to the south)- ammoniacal nitrogen. BH KTA018 sampled at 10.00m bgl (located 158m north of A66 near Dismantled railway to the south), BH KTA021 sampled at 3.50m bgl (located 19m south of A66 near Dismantled railway to the north)- sulphate, sodium, and TPH CWG.	Exceedance concentrations recorded for ammoniacal nitrogen, sulphate, sodium and TPHCWG.
Surface water		-	No surface waters are located in close proximity to the scheme (adjacent and/or <50m).	-	-

Ground Gas

9.7.83 A field monitoring was undertaken between 26 May 2021 and 23 June 2021 as part of the GI. The recorded methane concentrations ranged between 0.0 and 0.3 % volume. Carbon dioxide concentrations between 0.0 and 4.8 % volume, none exceeded the 5 % Action Level, however, the response zone was flooded with groundwater at BH KTA015 (located 656m north of A66), hence, the results are considered unreliable. Oxygen levels were between 0.0 and 21.1 % with very low flow rates recorded (0.1-0.3 l/h).

Summary

9.7.84 The human health and controlled waters risk assessments, carried out and detailed in GIR Package A - Temple Sowerby to Appleby and Appleby to Brough ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4), indicates there is low risk from land affected by contamination within the Temple Sowerby to Appleby study area. The chemical results and subsequent quantitative risk assessment showed that there is low risk to human health receptors within the scheme. The controlled waters risk assessment indicates a number of exceedances of Tier 1 and Tier 2, presenting a low risk to controlled waters. No surface waters are located in close proximity to the scheme. Overall, recorded exceedances within the study area were not located within zone 1 of the route alignment.

Soils

9.7.85 Published soil mapping shows mainly as Clifton Association with the Temple Sowerby to Appleby scheme. They are typically slowly permeable clayey soils and in this part of the country fall into WC 4 (ALC Grade 3b or Grade 4) but contain 30% of subordinate soils (i.e., Salwick and Quarndon), which are better drained and fall into WC 2 and 3 and so ALC Grade 2 and 3a.

9.7.86 In the central areas within the Temple Sowerby to Appleby scheme, Enborne and Wick 1 Association are mapped. Enborne Association are typically slowly permeable clayey soils in valleys, and in this part of the country fall into WC 3 and 4 (ALC Grade 3a/b or 4). Wick 1 Association typically have deep well drained coarse loamy soils and are well to moderately well drained and in this part of the country fall into WC 1 or 2 and so into ALC Grade 2.

9.7.87 The soil survey from Temple Sowerby to Appleby was carried out between 9 February and 10 March 2022 and comprised 195 number of survey locations. Access was not granted for survey of a further 14 number locations due to livestock in the fields at the time. A sufficient number of sample locations were accessed to enable a land classification value.

9.7.88 The soils vary across this section with soils in the western half generally being lighter in texture than those in the eastern half. A typical lighter soil has a brown medium sandy loam topsoil 30-43cm deep over upper and lower subsoils extending to 120cm plus depth which have variable

textures of brown medium sand, medium sandy loam, sandy clay loam and sandy clay. The topsoil tends to be very slightly stony and the lower subsoil moderately stony. The soils are mostly well drained.

9.7.89 A typical heavier soil in the east of the scheme has a grey-brown medium clay loam or sandy clay loam topsoil varying in depth from 20-35cm. The upper subsoil is grey brown or dark brown which ochreous mottles extending to variable depth over mainly pale brown or pale reddish brown heavy clay loam or occasionally clay, sandy clay or sandy loam lower subsoil extending to 100cm plus. These soils are either imperfectly or poorly drained. The soil grades distribution across the scheme and receptor value (sensitivity) are summarised in Table 9-20: Soil resources - Temple Sowerby to Appleby

Table 9-20: Soil resources - Temple Sowerby to Appleby

Soil grades present within the Order Limits	Permanent land take within the Order Limits	Temporary land take within the Order Limits	Total area of each grade within Order Limits	*DMRB LA 109*[1] Receptor Value (Sensitivity)
Grade 1	n/a	n/a	None identified	n/a
Grade 2	43.9ha	28.8ha	72.7 (34%)	Very High
Grade 3 subgrade 3a	27.2ha	19.0ha	46.2 ha (20%)	High
Grade 3 subgrade 3b	35.9ha	10ha	45.9ha (22%)	Medium
Grade 4	0.4ha	<0.1ha	0.5ha (0.2%)	Low
Non-agricultural	6.4ha	0.6ha	7.5ha (3%)	Negligible
Urban	27.9ha	3.1ha	30.9ha (15%)	Negligible
Not surveyed	6.8ha	2.9ha (	9.7ha (5%)	n/a

9.7.90 The ALC survey recorded >50% of the area surveyed is formed of soil of Agricultural Land Classification Grades 2 and 3a (BMV land) in the Temple Sowerby to Appleby scheme within the Order Limits. Over 70ha of the Grades 2 and 3a soils of BMV land will be within permanent land take. Approximately 50ha of Grade 2 and 3a soils will be within the area required temporary construction land take.

Appleby to Brough

Geological context

9.7.91 Published geology Appleby to Brough is mapped as Made Ground, followed by natural superficial deposits comprising Glacial Till and Alluvium. The mapped bedrock below the scheme comprises the Penrith Sandstone Formation.

Geodiversity sites

9.7.92 The Project is located on the very southern edge of the UNESCO Global Geopark (very high value) receptor, see ES Figure 9.4: Geodiversity Sites (Application Document 3.3). The UNESCO Global Geopark has

the same boundary as the designated Area of Outstanding Natural Beauty of the North Pennines. The UNESCO Global Geopark has a very high sensitivity, although only approximately 2km^2 of the Geopark is within the study area for the Appleby to Brough (Warcop) scheme compared to the total Geopark area of 1,983km^2.

9.7.93 George Gill SSSI, a natural exposure in the Lower Permian Penrith Sandstone, is present close to the study area but not within it, located to the west of Appleby and approximately 300m to the north-northwest of the scheme. This site lies outside the study area and will not be directly disturbed as a result of the scheme and therefore has not been considered as a receptor.

Contamination sources

9.7.94 Potentially contaminative sites have been identified which could be impacted by the Project, including MoD land, military coal storage a railway, farms, sewage discharge consent, a refuelling facility and garage, as detailed in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). The potential contaminated sites for this scheme are prefixed CL06- in the appendix.

Contamination receptors

9.7.95 Potential receptors to contamination have been identified in the study area. These include the residents of nearby properties, Warcop MoD training ground, a principal aquifer, and surface watercourses including the River Eden, as detailed in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). Further information on groundwater and surface water receptors is provided in ES Chapter 14: Road Drainage and the Water Environment.

9.7.96 The greatest risk to controlled waters (groundwater-principal aquifer) is associated with MoD land (moderate risk during baseline conditions), the petrol filling station, farms, and landfill sites posing a moderate/low risk under current baseline conditions. The impact at these locations has been assessed as either neutral or minor adverse effect due to the potential for ground disturbance during construction and contaminant mobilisation/migration.

9.7.97 The assessed risks to receptors associated with the MoD land are generally not applicable to medium with a neutral impact during construction of the Project. This is due to the low likelihood that contamination is present, or if present is very limited, associated with these land use sources.

9.7.98 The scheme passes through the southern boundary of the UNESCO Global Geopark and North Pennines AONB and to the south of the North Pennine Special Protected Area (SPA) and SAC.

9.7.99 There are two designated ecological receptors within the study area, the River Eden SAC and the River Eden Tributaries SSSI, for this scheme

located within 40m of the Order Limit south of the scheme. Further detail on these statutory designated sites, and their qualifying habitats and vegetative communities, is provided in Chapter 6: Biodiversity.

Ground investigation

9.7.100 A programme of ground investigation took place between 15 February 2021 and 28 April 2021. Key findings relevant to this chapter are presented below. The full details of the ground investigation and findings are reported in the GIR Package A-Temple Sowerby to Appleby and Appleby to Brough ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

Encountered ground conditions

9.7.101 A summary of the encountered ground conditions based on the ground investigation within the study area is provided Table 9-21: Summary of proven geology and ground conditions: Appleby to Brough.

Table 9-21: Summary of proven geology and ground conditions: Appleby to Brough

Strata	Proven depth range (mbgl)	Description
Superficial		
Made Ground Cohesive	-	Not encountered
Made Ground Granular	0.00-0.40	Typically associated with obvious man-made materials either from this source or from coarse till.
Granular Glacial Till	0.00-13.10	Clayey gravelly SAND and less often as clayey sandy GRAVEL
Fluvioglacial Till	0.30-8.00	Clayey or silty sandy GRAVEL
Cohesive Glacial Till-Sandy	0.00-10.45	Gravelly clayey SAND or gravelly sandy CLAY
Cohesive Glacial Till	0.00-16.20	Slightly gravelly sand CLAY, with a variable cobble content.
Sand	0.10-14.00	Slightly gravelly clayey fine to coarse sand.
Bedrock		
Penrith Sandstone	2.00-42.00	Very weak or extremely weak on the basis of its cores.

Encountered groundwater conditions

9.7.102 Groundwater was observed in a number of exploratory holes with a response zone depth range of 1.00 to 25.00m bgl. Water strikes and standing water levels were encountered. Details are presented on the borehole logs in GIR Package B-M6 Junction 40 to Kemplay Bank and Penrith to Temple Sowerby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

9.7.103 No karstic features were identified from the Light Detection and Ranging (LiDAR) and aerial photography stage of the karst assessment.

However, a walkover conducted as part of the assessment did identify a seepage karst feature. Boggy ground is located in the area of a spring labelled on OS mapping and had therefore been labelled as groundwater to surface water interaction. The location is situated on the Great Scar Limestone Group; although the specific location is not included in the *A66 Northern Trans-Pennine Preliminary Environmental Information Report*[20], the limestone group is located outside of the study area. As discussed in Section 9.4: Assessment methodology, a risk-based approach will be taken in the ES to capture impacts on receptors that lie outside the 250m study area boundary.

GI chemical testing overview

9.7.104 Geo-environmental testing of Made Ground and natural strata has been carried out within the Appleby to Brough study area, full details of which are given in GIR Package A-Temple Sowerby to Appleby and Appleby to Brough ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4) and key findings are summarised below.

9.7.105 Groundwater and surface water samples were also collected for analysis.

9.7.106 Visual evidence of contamination during the ground investigation predominantly comprised fragments of man-made ash and gravel in Made Ground strata located in BH AB010 (on A66, 200m north of Eden Valley Railway), BH AB015 (on A66, 218m north of Eden Valley Railway), which are of considerable disctance from the works, therefore posing very little risk . BH AB030 (south of A66 on MoD land) and TP AB029 (31m south of A66 close to MoD land to the east) are nearer to the scheme , with monor exceedances. The risk is considered low with the application of mitigation measures. Table 9-22: Summary of chemical analysis of samples from Appleby to Brough presents a summary of the GI sampling, analysis along with the findings of preliminary assessment.

Table 9-22: Summary of chemical analysis of samples from Appleby to Brough

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
Soil	189 (comprising 53 from Topsoil, 17 from Made Ground, and 119 from natural superficial deposits)	Primary metals and metalloids, secondary metals and metalloids, inorganics, CN/Phenol analysis, TPH CWG, speciated PAHs, SVOCs and VOCs testing.	No samples were recorded as exceeding the POSPark assessment criteria.	-	-
Soils - Asbestos	69 (comprising Topsoil, Made Ground, and natural superficial deposits)	Asbestos (presence and identification and quantification)	No asbestos was detected within samples examined in the laboratory. No asbestos containing materials were observed during ground investigation.	-	-
Soils - Leachate	88 (comprising Topsoil, Made Ground, and natural superficial deposits)	pH, electrical conductivity, total dissolved solids, chloride, fluoride, sulphate, DOC, metals, phenols	pH, conductivity, chloride, arsenic, copper, lead, molybdenum, nickel, and zinc were recorded as exceedances screened against CWRA using the lowest available WQS (i.e., DWS or EQS) of	TP AB005 Dark greyish brown clayey fine to coarse sand sampled at 0.50m bgl (located 118m south of A66 near Historic Gravel Pit to the south), TP AB012 Sand sampled at 0.60m bgl (located 11m south of A66)-arsenic, chromium, lead and nickel. TP AB052 Slightly gravelly clayey sand sampled at 1.20m bgl (located 132m south of A66 near Broomrigg House to the east), TP AB055 Topsoil-slightly gravelly clayey sand sampled at 0.20m bgl	Leachate testing identified minor exceedances of arsenic, chromium, lead, and nickel which are naturally likely to be lower – this is confirmed by the absence of lead in groundwater

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
			Tier 1 and 2 (86 samples). Soil leachate tests do not simulate in-situ conditions and concentrations from soil leachate tests are considered conservative. Therefore, these were progressed to Tier 2 assessment. Minor exceedances of Tier 2 criteria for arsenic, chromium, lead, and nickel (34 samples)	(located 30m south of A66 near outhouses Farm to the north)-arsenic and lead. BH AB019 Topsoil-slightly gravelly sandy clay sampled at 0.50m bgl (located 123m south of A66)-lead and nickel. TP AB001 Topsoil sampled at 0.20m bgl (located 16m south of A66), TP AB002 Clayey gravelly sand sampled at 0.50m bgl (located 311m south of A66), TP AB011 Greyish brown slightly gravelly clayey fine to coarse sand-Made Ground sampled at 0.60m bgl (located 26m south of A66), TP AB015 Topsoil-dark brown silty fine to coarse sand with frequent roots and rootlets sampled at 0.20m bgl (located 174m south of A66 near Eden Valley Railway to the south), TP AB019 Slightly gravelly clayey sand sampled at 0.50m bgl (located 85m south of A66), TP AB020 Slightly gravelly clayey sand sampled at 0.50m bgl (located 68m south of A66 near Construction equipment to the west), TP AB025 Gravelly clayey sand sampled at 0.60m bgl (located 133m south of A66 near Orchard to the north-east), TP AB026 Topsoil slightly gravelly clayey sand sampled at 0.20m bgl (located 10m south of A66), TP AB027 Gravelly clayey sand sampled at 0.20m bgl (located 100m south of A66), TP AB030 possible Made Ground-slightly sandy slightly gravelly clay sampled at 0.20m bgl (located 16m south of A66 near MoD Diesel Tanks to the north), TP AB033 Slightly gravelly clayey sand sampled at 0.60m bgl	samples from the same locations. .

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
				(located 72m south of A66), TP AB037 Slightly gravelly clayey sand with low cobble content sampled at 1.50m bgl (located 27m south of A66 near MoD land), TP AB041 Gravelly clayey sand sampled at 0.60m bgl (located 97m south of A66), TP AB042 Topsoil-slightly gravelly clayey sand. Gravel of mixed lithologies sampled at 0.20m bgl (located 40m south of A66), TP AB046 Slightly gravelly sandy clay sampled at 0.50m bgl (located 29m south of A66), TP AB048 Slightly gravelly very clayey fine to coarse sand sampled at 1.00m bgl (located 72m south of A66 near Broomrigg House Farm to the south-west), TP AB049 Topsoil-slightly gravelly clayey sand sampled at 0.20m bgl (located 28m south of A66 near Broomrigg House Farm to the south-west), TP AB050 Slightly gravelly clayey sand sampled at 0.60m bgl (located 38m south of A66 near Broomrigg House Farm to the south), TP AB054 Topsoil-slightly gravelly clayey sand sampled at 0.20m bgl (located 121m south of A66), TP AB056 Slightly gravelly sandy clay sampled at 0.50m bgl (located 29m south of A66), BH AB025 Clayey fine to coarse sand sampled at 0.20m bgl (located 34m south of A66 on Air Ambulance Helipad site), BH AB026 Clayey gravelly sand sampled at 1.20m bgl (located 39m south of A66 near Air Ambulance Helipad to the east), BH AB031 Topsoil-slightly gravelly sand sampled at 0.20m bgl (located 35m south of A66 near Air Ambulance Helipad to the east), BH AB033 Slightly gravelly sand sampled at 0.50m bgl (located 49m south of A66), BH AB039 Silty clayey sand sampled	

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
				at 1.20m bgl (located 23m south of A66 near), BH AB042 Slightly gravelly very clayey sand sampled at 0.50m bgl (located 10m south of A66 near Outhouses Farm to the north), BH AB046 Slightly sandy gravelly clay sampled at 1.00m bgl (located 30m south of A66), TP AB borrowpit01 Topsoil sampled at 0.20m bgl (located 171m north of A66)-lead.	
Groundwater	20	Metals and metalloids, secondary metals and metalloids, major ions, ammoniacal nitrogen, electrical conductivity, total suspended solids, oxygen demand, TPH CWG, Speciated PAHs.	Exceedances of the Tier 1 groundwater criteria for conductivity, ammoniacal nitrogen, chloride, copper, sodium, TPH CWG (18 samples). Therefore, these were progressed to Tier 2 assessment. Exceedances of Tier 2 criteria for conductivity, chloride, nitrite, nitrate, arsenic, sodium, and TPH CWG (9 samples).	BH AB008 sampled at 3.70-5.20m bgl (located 171m south of A66)-conductivity and TPH CWG. BH AB009 sampled at 11.00-12.00m bgl (located 25m north of A66)-conductivity, nitrite, sodium and chloride. BH AB043 sampled at 1.50m bgl (located 43m south of A66 near Outhouse Farm to the north)-chloride and TPH CWG. BH AB026 sampled at 6.00m bgl (located 33m south of A66 near Air Ambulance Helipad to the east)-chloride and sodium. BH AB042 sampled at 3.00m bgl (located 10m south of A66 near Outhouses Farm to the north)-chloride. BH AB033 sampled at 3.60m bgl (located 50m south of A66)-nitrite and nitrate.	The exceedances concentrations recorded are unlikely to pose a significant risk, as no corresponding detectable concentration was recorded within the soil samples from those locations.

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
				BH AB032 sampled at 6.00m bgl (located 18m south of A66)-nitrate. BH AB025 sampled at 12.00m bgl (located 34m south of A66 on Air Ambulance Helipad site)-arsenic. BH AB043 sampled at 1.50m bgl (located 43m south of A66 near Outhouse Farm to the north)-TPH CWG.	
Surface water (unnamed tributary of River Greta)	5	Metals and metalloids, secondary metals and metalloids, major ions, ammoniacal nitrogen, electrical conductivity, total suspended solids, oxygen demand, TPH CWG, Speciated PAHs, Phenols and Cyanides	Exceedances of the Tier 1 surface water criteria for conductivity, ammoniacal nitrogen, chloride, copper, zinc, sodium, TPH CWG (5 samples). Therefore, these were progressed to Tier 2 assessment. Exceedances of Tier 2 criteria for ammoniacal nitrogen, copper and zinc.	SW BH AB043. SW BH AB026- ammoniacal nitrogen and copper. SW BH AB025-copper and zinc. SW BH AB021, SW BH AB028-copper	Recorded exceedance for copper and marginal exceedances for ammoniacal nitrogen and zinc.

Ground gas

9.7.107 A field monitoring was undertaken between 26 May 2021 and 23 June 2021 as part of the GI. The recorded methane concentrations ranged between 0.0 and 0.7 % volume. Carbon dioxide concentrations between 0.0 and 7.6 % volume, only exceeding the 5 % Action Level on two occasions (BH AB020 located on A66, 21m south of Orchard and BH AB045 located on A66, 554m north of Lowgill Farm), however, the response zone was flooded with groundwater at eight boreholes (BH AB001 located on A66, 497m south of Eden Valley Railway, BH AB008 located 171m south of A66, BH AB009 located 25m north of A66, BH AB025 located 34m south of A66 on Air Ambulance Helipad site, BH AB026 located 39m south of A66 near Air Ambulance Helipad to the east, BH AB027 located 61m south of A66, near Eden Valley Railway to the south and BH AB044 located on A66, 84m south of Farm (outhouses) to the north. Due to the groundater levels the results are considered unreliable. Oxygen levels were between 3.9 and 21.3 % with very low flow rates recorded (0.0-0.6 l/h).

Summary

9.7.108 The human health and controlled waters assessments, carried out and detailed in the GIR Package A-Temple Sowerby to Appleby and Appleby to Brough ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4), indicates there is low risk from land affected by contamination within the Appleby to Brough study area. The chemical results and subsequent quantitative risk assessment showed that there is low risk to human health receptors within the scheme. The controlled waters risk assessment indicates a number of exceedances of Tier 1 and Tier 2, unlikely to present significant risk as no corresponding detectable concentration was recorded within soil samples from those locations. A low risk is also presented from surface water marginal exceedances. Overall, recorded exceedances within the study area were not located within zone 1 of the route alignment.

Soils

9.7.109 Published soil mapping show in the Wick 1 Association soil type across the majority of the Appleby to Brough scheme. They typically have deep well drained coarse loamy soils and are well to moderately well drained and in this part of the country fall into WC 1 or 2 and so into ALC Grade 3a for the western and central areas of the scheme and Grade 3b for the eastern end of the scheme.

9.7.110 A small area to the west is mapped as Crannymore. These soils are well drained sandy soils and can be affected by groundwater. They typically fall into WC 1 (ALC Grade 3a) when they are drained, and the regional water table has been lowered and WC 4 (ALC Grade 3b) if undrained.

9.7.111 To the east of the scheme a small area of Clifton Association is mapped close to Langrigg. These soils are typically slowly permeable clayey soils which fall into WC 4 (ALC Grade 3b or 4) but contain 30% of

subordinate soils (i.e., Salwick and Quarndon) which are better drained and fall into WC 2 and 3 (ALC Grade 3b or 4).

9.7.112 The soil survey from Appleby to Brough was carried out between 9 February and 15 March 2022 and comprised 138 number of survey locations. Access was not granted for survey of a further 20 number locations due to livestock in the fields at the time. A sufficient number of sample locations were accessed to enable a land classification value.

9.7.113 The survey found the soils in this scheme to be very variable and it is not possible to give any meaningful generic description of a soil profile in the scheme. The soils vary from well drained to poorly drained. The sandy textures and colours vary in well drained profiles across the scheme as do the clayey textures and colours in imperfectly and poorly drained profiles. In two areas on the scheme steep gradient was identified as a limitation to agriculture use of the land (ALC Grade 4) and in one area flooding was a limitation (ALC Grades 4 & 5). The ALC grade of land in this scheme is limited to a maximum of Subgrade 3a by a climatic limitation. The soil grades distribution across the scheme and receptor value (sensitivity) are summarised in Table 9-23: Soil resources - Appleby to Brough.

Table 9-23: Soil resources - Appleby to Brough

Soil grades present within the Order Limits	**Permanent land take within the Order Limits**	**Temporary land take within the Order Limits**	**Total area** of each grade **within Order Limits**	***DMRB LA 109***[1] **Receptor Value (Sensitivity)**
Grade 1	n/a	n/a	None identified	n/a
Grade 2	n/a	n/a	None identified	n/a
Grade 3 subgrade 3a	24.8ha	19.1ha	43.9ha (24%)	High
Grade 3 subgrade 3b	49.1ha	15.9ha	65.0ha (36%)	Medium
Grade 4	15.0ha	6.6ha	21.6ha (12%)	Low
Grade 5	3.4ha	2.4ha	5.8ha (3%)	Low
Non-agricultural	13.4ha	0.5ha	13.5ha (8%)	Negligible
Urban	19.2ha	1.7ha	20.9ha (11%)	Negligible
Not surveyed	7.2ha	4.1ha	11.3ha (6%)	n/a

9.7.114 The ALC survey recorded <30% of the area surveyed is formed of soil of Agricultural Land Classification Grade 3a (BMV land) in the Order Limits of the Appleby to Brough scheme. 24.8ha of BMV land will be within permanent land take. 19.1ha of Grade 3a will be within the area required temporary construction land take. No soils of ALC Grade 1 or 2 were recorded in this scheme.

Bowes Bypass

Geological context

9.7.115 The published geological mapping is indicated to be underlain by Made Ground, followed by natural superficial deposits comprising Alluvium, River Terrace Gravels, Glaciofluvial deposits and Glacial Till. The bedrock below the scheme comprises sequence of the Stainmore Formation, the Great Limestone Member, the Alston Formation and the Four Fathom Limestone Member moving from west to east.

Geodiversity sites

9.7.116 The western edge of the scheme partly extends into the AONB/UNESCO Global Geopark, see ES Figure 9.4: Geodiversity Sites (Application Document 3.3). The North Pennines UNESCO Global Geopark is desiganted due to its internationally significant geology and geological hertigate. UNESCO Global Geoparks are places where outstanding geologial heritage is used to support sustainable development, through conservation, education, interpretation and nature tourism. Such sites have the highest receptor value of very high sensitivity. The scheme is located on the southern boundary of the Geopark. Approximately 0.3km^2 of the Geopark is within the Order Limits for the Appleby to Brough scheme compared to the total Geopark area of 1,983km^2.

Contamination sources

9.7.117 Following screening of these sites, a number of potentially contaminative sites have been identified which could be impacted by the Project, including a disused quarry, cemetery, railway land, garages, farms and a landfill, as detailed in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). The potential contaminated sites for this scheme are prefixed CL07- in the appendix.

Contamination receptors

9.7.118 Potential receptors to contamination have been identified in the study area. These include allotments, a primary school, Secondary A aquifers, and numerous surface watercourses, detailed in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). Further information on groundwater and surface water receptors is provided in Chapter 14: Road Drainage and the Water Environment.

9.7.119 The Project is located at the eastern edge of the North Pennines AONB/ UNESCO Global Geopark. The North Pennines Moors SAC, the North Pennines Moors SPA and the Bowes Moor SSSI are located 300m and 350m north-west and are immediately outside the study area. Further detail on these statutory designated sites, and their qualifying habitats and vegetative communities, is provided in Chapter 6: Biodiversity.

Ground investigation

9.7.120 A programme of ground investigation took place between 1 February 2021 and 10 March 2021. Key findings relevant to this chapter are presented below. The full details of the ground investigation and findings are reported in *GIR Package D* -Bowes Bypass and Cross Lanes to Rokeby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

9.7.121 The GI in the Bowes bypass study area comprised 12 cable percussion boreholes to a maximum depth of 8.50m, 11 cable percussion borehole with rotary follow on to a maximum depth of 20.30m, two rotary open hole and rotary core borehole to a maximum depth of 17.00m, two windowless sampling borehole to a maximum depth of 5.20m, and 14 machine-excavated trial pits to a maximum depth of 4.50m.

Encountered ground conditions

9.7.122 A summary of the encountered ground conditions based on the ground investigation within the study area is provided in Table 9-24: Summary of proven geology and ground conditions: Bowes Bypass

Table 9-24: Summary of proven geology and ground conditions: Bowes Bypass

Strata	Proven depth range (mbgl)	Description
Superficial		
Topsoil	0.00-0.70	Soft sandy slightly gravelly clay with rootlets.
Made Ground Cohesive and Granular	0.15-0.80	Clayey slightly gravelly sand and frequently included rootlets
Glacial Deposits-Cohesive	0.30-5.10	Firm to stiff with depth, grey, brown slightly sandy slightly gravelly clay with medium cobble content.
Glacial Deposits-Granular	2.90-5.50	Brown very clayey slightly gravelly sands and clayey sandy gravels.
Bedrock		
Mudstone (Stainmore Formation)	0.50-13.60	Weak, grey and distinctly weathered, and increasing in strength to medium strong or strong with depth.
Limestone (Great Limestone Formation)	4.30-20.00	Very strong and distinctly weathered (becoming partially weathered with depth).
Sandstone (Alston Formation)	10.60-20.30	Moderately weak and partially weathered.

Encountered groundwater conditions

9.7.123 Groundwater was observed in a number of exploratory holes with a response zone depth range of 1.30 to 8.50m bgl. Water strikes in both the mudstone bedrock and superficial deposits and standing water levels were encountered. Details are presented on the borehole logs in GIR Package B-M6 Junction 40 to Kemplay Bank and Penrith to Temple

Sowerby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

9.7.124 Baseline studies identified ten potential karst landforms outside of the study area. No karst features were identified under the alignment itself.

GI chemical testing overview

9.7.125 Geo-environmental testing of Made Ground and natural strata that has been carried out within the Bowes bypass study area. Full details of which are given in the *GIR Package D* -Bowes Bypass and Cross Lanes to Rokeby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4), and key findings are summarised below.

9.7.126 Groundwater and surface water samples were also collected for analysis.

9.7.127 Visual and olfactory evidence of contamination during the ground investigation predominantly comprised varying amounts of coal and ash locally within Made Ground.

9.7.128 Table 9-25: Summary of chemical analysis of Bowes Bypass samples presents a summary of the GI sampling, analysis along with the findings of preliminary assessment.

Table 9-25: Summary of chemical analysis of Bowes Bypass samples

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
Soil	56 (comprising 7 from Topsoil, 15 from Made Ground, and 42 from Glacial and 1 Mudstone sample)	Primary metals and metalloids, inorganics, CN/Phenol analysis, TPH CWG, speciated PAHs and WAC testing	Arsenic was recorded as exceeding the Public Open Space Park (POSPark) assessment criteria. (2 samples of Glacial Deposit)	TP BB004 Subsoil sampled at 0.30m bgl (historical presence of old railway, located 53m north of A66) TP BB010 Natural Yellow clay sampled at 1.00m bgl (Historical presence of old railway, located 23m north of A66) (Glacial Deposit soil type).	Whilst these exceedances are shallow, the primary exposure pathway for arsenic is via direct contact.
Soils - Asbestos	44 (comprising Topsoil, Made Ground, and natural superficial deposits)	Asbestos (presence and identification and quantification)	No asbestos was detected within samples examined in the laboratory. No asbestos containing materials were observed during ground investigation.	-	-
Soils - Leachate	21 (comprising Topsoil, Made Ground, and natural superficial deposits)	Electrical Conductivity, Total Dissolved Solids, Chloride, Fluoride, Sulphate, DOC, Metals, Phenols	Molybdenum (10 samples) Zinc (2 samples) and Copper (8 samples) were recorded as exceedances screened against CWRA using the lowest available WQS (i.e., DWS or EQS) of Tier 1 and 2 Soil leachate tests do not simulate in-situ conditions and concentrations from soil leachate tests are considered conservative. Due to this, the		Leachate testing identified exceedances of copper, zinc, and molybdenum.

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
			exceedances have not been progressed to a Tier 2 assessment but are qualitatively assessed		
Groundwater	2	Metals and metalloids, major ions, ammoniacal nitrogen, total suspended solids, oxygen demand, TPHCWG, BTEX, Speciated PAHs, Phenols and Cyanides	Marginal exceedances of the Tier 1 groundwater criteria for zinc, copper ammoniacal nitrogen and pyrene Therefore, these were progressed to Tier 2 assessment. Marginal exceedances of Tier 2 criteria for zinc, copper and ammoniacal nitrogen.	BH BB007 sampled at 4.45m bgl (located 40m north of A66) - Zinc, copper and ammoniacal nitrogen BH BB013 sampled at 2.85m bgl (located 68m north of A66 near Disused railway to the south)-Pyrene	Zinc - no attributable source of contamination present in the soils impacting controlled waters within the area exceedance attributed to general diffuse pollution. Pyrene -location is situated within an area historically associated with the former rail station. However, it was deemed no significant source of contamination is impacting controlled waters within the area
Surface water (unnamed tributary of River Greta)	2	Metals and metalloids, major ions, ammoniacal nitrogen, total suspended solids, oxygen demand, TPHCWG, BTEX, Speciated PAHs, Phenols and Cyanides	No surface water samples were recorded as exceeding controlled waters Tier 1 criteria.	-	-

Ground gas

9.7.129 No potentially significant sources of ground gas were identified ahead of the GI and based on the findings of the investigation, the Made Ground at the site is considered to have limited gassing potential therefore deemed negligible risk and no ground gas monitoring was undertaken.

Summary

9.7.130 The human health and controlled waters risk assessments, carried out and detailed in the GIR Package D -Bowes Bypass and Cross Lanes to Rokeby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4), indicates there is low risk from land affected by contamination within Bowes Bypass study area. The chemical results and subsequent quantitative risk assessment showed that there is low risk to human health receptors within the scheme. The controlled waters risk assessment indicates a number of exceedances of Tier 1 and Tier 2; however, it was deemed no significant source of contamination is impacting controlled waters within the area and no surface water samples exceeded the Tier 1 criteria. Overall, recorded exceedances within the study area were not located within zone 1 of the route alignment.

Soils

9.7.131 Published maps show Brickfield 3 in the Bowes Bypass area which are typically consist of slowly permeable seasonally waterlogged fine loamy over clayey soils and in this part of the country are likely to fall into WC 4 and so into ALC Grade 3b or 4. The soils to the east of the area are mapped as Dunkeswick they typically consist of slowly permeable seasonally logged fine loamy over clayey soils they are likely to fall into WC 4 and into ALC Grade 3b or 4.

9.7.132 Bowes Bypass soil survey was carried out between 7 February and 1 March 2022 and comprised 16 number of survey locations. Access was not granted for survey of a further one location due to livestock in the fields at the time.

9.7.133 The soils on this scheme have dark or very dark greyish brown medium clay loam, silty clay loam or sandy clay loam, sometimes organic, topsoil varying from 15-30cm deep over brown heavy or medium clay loam upper subsoil with ochreous mottles to 38-50cm depth over greyish brown or grey heavy clay loam or clay lower subsoil with ochreous mottles to 100cm plus depth. The soils are imperfectly or poorly drained. The ALC Grade of this land is limited to a maximum of Subgrade 3b due to a climatic limitation. The soil Grades distribution across the scheme and receptor value (sensitivity) are summarised in Table 9-26: Soil resources - Bowes BypassTable 9-26: Soil resources - Bowes Bypass.

Table 9-26: Soil resources - Bowes Bypass

Soil grades present within the Order Limits	Permanent land take within the Order Limits	Temporary land take within the Order Limits	Total area of each grade within Order Limits	*DMRB LA 109*[1] Receptor Value (Sensitivity)
Grade 1	n/a	n/a	None identified	n/a
Grade 2	n/a	n/a	None identified	n/a
Grade 3 subgrade 3a	n/a	n/a	None identified	n/a
Grade 3b	19.5ha	15.9	37.4ha (64%)	Medium
Grade 3 subgrade 3b	n/a	n/a	None identified	n/a
Grade 4	n/a	n/a	None identified	n/a
Grade 5	0ha	0ha	0ha (0%)	Negligible
Urban	18.6ha	1.6ha	21.3ha (36%)	Negligible
Not surveyed	0ha	0ha	0ha (0%)	Negligible

9.7.134 The ALC survey recorded no soil of Agricultural Land Classification Grades 1, 2 or 3a (BMV land) in the Bowes Bypass Order Limits.

Cross Lanes to Rokeby

Geological context

9.7.135 The published geology for Cross Lanes to Rokeby is mapped as Made Ground, followed by natural superficial deposits comprising predominantly Glacial Till and some Alluvium. The anticipated bedrock below the scheme comprises of the Great Limestone Member as the geological boundary runs to the south and roughly parallel to the alignment. The bedrock geology is mapped as sandstone beds of the Alston Formation.

Geodiversity sites

9.7.136 No geodiversity sites have been identified in the study area.

Contamination sources

9.7.137 Following screening of these sites, a number of potentially contaminative sites have been identified which could be impacted by the Project, including potential fly tipping, a poultry house, discharge consents, farms and potential scrapyard, as detailed in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). The potential contaminated sites for this scheme are prefixed CL08- in the appendix.

Contamination receptors

9.7.138 A number of potential receptors to contamination have been identified in the study area. These include residents of nearby properties, Secondary A aquifers and small abstractions, and numerous surface watercourses,

see ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). Further information on groundwater and surface water receptors is provided in ES Chapter 14: Road Drainage and the Water Environment.

9.7.139 No statutory designated sites are located within the study area. Rokeby Park and Mortham Woods Local Wildlife Site are adjacent to this section. Further detail on potentially sensitive habitats and species within the study area is provided in Chapter 6: Biodiversity.

Ground investigation

9.7.140 A programme of ground investigation took place between 1 February 2021 and 10 March 2021. Key findings relevant to this chapter are presented below. The full details of the ground investigation and findings are reported in GIR Package D -Bowes Bypass and Cross Lanes to Rokeby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

9.7.141 The GI in the Cross Lanes to Rokeby study area comprised four cable percussion boreholes to a maximum depth of 8.50m, three cable percussion borehole with rotary follow on to a maximum depth of 20.30m, one rotary open hole and rotary core borehole to a maximum depth of 17.00m, three windowless sampling borehole to a maximum depth of 5.20m, and 18 machine-excavated trial pits to a maximum depth of 4.50m.

Encountered ground conditions

9.7.142 A summary of the encountered ground conditions based on the ground investigation within the study area is provided in Table 9-27: Summary of proven geology and ground conditions: Cross Lane to Rokeby.

Table 9-27: Summary of proven geology and ground conditions: Cross Lane to Rokeby

Strata	Proven depth range (mbgl)	Description
Superficial		
Topsoil	0.00-1.40	Brown very clayey slightly gravelly sand and soft dark brown slightly gravelly clay with many rootlets.
Made Ground Cohesive	0.15-1.40	Topsoil with stony clay and tarmac rubble or Topsoil with cobbles and boulders.
Glacial Deposits-Cohesive	0.40-11.50	Firm to stiff brown/orangish mottled slightly sandy slightly gravelly clay with cobbles.
Glacial Deposits-Granular	0.30-10.50	Grey/blue clayey gravelly sands and sands and gravels.
Bedrock		
Mudstone (Alston Formation)	14.20-16.45	Distinctly weathered extremely weak to very weak grey mudstone.

Strata	Proven depth range (mbgl)	Description
Interlaminated Sandstone, Siltstone and Mudstone	9.40-19.45	Moderately weak to moderately strong partially weathered interlaminated sandstone, siltstone and mudstone.

Encountered groundwater conditions

9.7.143 Groundwater was observed in a number of exploratory holes with a response zone depth range of 2.20 to 14.50m bgl. Water strikes in Glacial Deposits and standing water levels were encountered. Details are presented on the borehole logs in GIR Package B-M6 Junction 40 to Kemplay Bank and Penrith to Temple Sowerby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

9.7.144 LiDAR and aerial photography did not identify any karst landforms within the Great Limestone Member. Springs were identified from OS mapping but were discounted due to their occurrence within sandstone. The site walkover did encounter hummocky wet ground adjacent to a small tributary to Tutta Beck. The Karst assessment considers the Great Limestone Member to have a moderate karst risk. Although the Alston Formation was not considered within the original risk assessment for the Cross Lanes to Rokeby scheme, it was assessed for other schemes as having a low karst risk.

GI chemical testing overview

9.7.145 *G*eo-environmental testing of soils has been carried out within the Cross Lanes to Rokeby study area. Full details of which are given in the *GIR Package D* -Bowes Bypass and Cross Lanes to Rokeby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4) and key findings are summarised below.

9.7.146 Groundwater and surface water samples were also collected for analysis.

9.7.147 No Made Ground was encountered during the investigation. Coal was identified at shallow depth as a tertiary gravel component between Street Side Farm and Birk House Farm at TP CLR009A alongside other bedrock lithologies such as sandstone and mudstone. It is likely that these lithologies have been deposited naturally within the glacial deposits and the coal encountered is considered natural in origin due to the local presence of coal within the bedrock. Table 9-28: Summary of chemical analysis of Cross Lane to Rokeby samples presents a summary of the GI sampling, analysis along with the findings of preliminary assessment.

Table 9-28: Summary of chemical analysis of Cross Lane to Rokeby samples

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
Soil	35 (comprising 7 from Topsoil, 28 from Glacial samples)	Primary metals and metalloids, inorganics, CN/Phenol analysis, TPH CWG, BTEX, speciated PAHs and WAC testing	No samples were recorded as exceeding the POSPark assessment criteria.	-	-
Soils - Asbestos	25 (comprising Topsoil, Made Ground, and natural superficial deposits)	Asbestos (presence and identification and quantification)	No asbestos was detected within samples examined in the laboratory. No asbestos containing materials were observed during ground investigation.	-	-
Soils - Leachate	4 (comprising Topsoil, Made Ground, and natural superficial deposits)	Electrical Conductivity, Total Dissolved Solids, Chloride, Fluoride, Sulphate, DOC, Metals, Phenols	Copper (2 samples) Molybdenum (3 samples) and Mercury (1 sample) were recorded as exceedances screened against CWRA using the lowest available WQS (i.e., DWS or EQS) of Tier 1 and 2 Soil leachate tests do not simulate in-situ conditions and concentrations from soil leachate tests are considered conservative. Due to the incorporation of positive drainage and hardstanding by the proposed scheme, the exceedances have not been progressed to a Tier 2 assessment but are qualitatively assessed.	TP CLR013 Glacial deposits sampled at 0.20m bgl (located on A66 and 289m of Tutta Beck Farm to the south) and TP CLR020 Glacial deposits sampled at 1.00m bgl (located 113m south of A66)-Cu. TP CLR013 Glacial deposits sampled at 0.20m bgl (located on A66 and 289m of Tutta Beck Farm to the south), TP CLR009 Glacial deposits sampled at	

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
			Leachate testing identified exceedances of copper, molybdenum, and mercury.	1.20m bgl (located 38m south of A66 and 197m of Birk House Farm to the south) and TP CLR005 Glacial deposits sampled at 1.20m bgl (located 55m south of A66 near Farm (The Cottage))-Molybdenum. TP CLR020 Glacial deposits sampled at 1.00m bgl (located 113m south of A66)-Mercury	
Groundwater	1	Metals and metalloids, major ions, ammoniacal nitrogen, total suspended solids, oxygen demand, TPHCWG, BTEX, Speciated PAHs, Phenols and Cyanides	Marginal exceedances of the Tier 1 groundwater criteria for ammoniacal nitrogen, acenaphthene, fluorene, phenanthrene and pyrene. Benzo(k) fluoranthene, chrysene and copper were recorded as exceedances. Therefore, these were progressed to Tier 2 assessment. Marginal exceedances of Tier 2 criteria for acenaphthene, fluorene, phenanthrene and pyrene	BH CLR003A sampled at 5.00-7.00m bgl (located 27m south of A66)- ammoniacal nitrogen, acenaphthene, fluorene, phenanthrene and pyrene.	Whilst these PAHs were recorded as exceedances, it should be noted that the criteria used (limit of detection) are conservative.

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
Surface water (unnamed tributary of River Greta)	2	Metals and metalloids, major ions, ammoniacal nitrogen, total suspended solids, oxygen demand, TPHCWG, BTEX, Speciated PAHs, Phenols and Cyanides	Marginal exceedances of the Tier 1 surface water criteria for copper, benzo(g,h,i)perylene and chrysene. Therefore, these were progressed to Tier 2 assessment. Marginal exceedances of Tier 2 criteria for copper, chrysene and benzo(g,h,i)perylene.	SW CL001-copper, SW CLR002-benzo(k) fluoranthene, and chrysene. SW CLR001-copper, and SW CLR002-copper, chrysene, and benzo(g,h,i)fluoranthene.	The exceedances observed within surface water are significantly less than those in groundwater, suggesting that groundwater is not currently adversely affecting surface waters.

Ground gas

9.7.148 No potentially significant sources of ground gas were identified within the baseline study. No Made Ground was encountered across the 35 exploratory locations for the scheme. No highly organic materials were encountered in natural strata and whilst a thin band of coal was encountered in one location (BH CLR004a, 74m south of A66 and 62m west of Farm-The Cottage), it is not considered thick or laterally continuous. Therefore, the site is considered to have no gassing potential and therefore no ground gas monitoring was undertaken for this scheme.

Summary

9.7.149 The human health and controlled waters risk assessments, carried and detailed in the GIR Package D -Bowes Bypass and Cross Lanes to Rokeby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4), indicates there is low risk from land affected by contamination within the Cross Lanes to Rokeby study area. The chemical results and subsequent quantitative risk assessment showed that there is low risk to human health receptors within the scheme. The controlled waters risk assessment indicates a number of exceedances of Tier 1 and Tier 2, presenting a low risk to controlled waters with surface water exceedances significantly less than those in groundwater. Overall, recorded exceedances within the study area were not located within zone 1 of the route alignment.

Soils

9.7.150 Published soils mapping shows the Wick 1 Associationis present across the Cross lanes to Rockeby scheme. These soils typically have deep well drained coarse loamy soils and are well to moderately well drained and in this part of the country fall into WC 1 or 2 and so into ALC Grade 3a for the majority of the area, ALC Grade 2 in the far east of the scheme and ALC Grade 3b in the far west of the scheme.

9.7.151 The survey was carried out between 7 February and 28 February 2022 and comprised nine number of survey locations. Access was not granted for survey of a further 62 number locations due to livestock in the fields at the time. A sufficient number of sample locations were accessed to enable a land classification value.

9.7.152 The limited amount of surveying on this scheme was at the west end with one location towards the east end. The surveyed locations had dark grey or greyish brown medium clay loam or silty clay loam topsoil with a few ochreous mottles which are 24-30cm over yellow brown or light brown medium clay loam upper soil with ochreous, light grey and yellow mottles down to 32-50cm deep over very dark grey heavy clay loam or clay lower subsoil with ochreous and yellow mottles to 100cm plus depth. The soils are poorly drained. The west end, centre and east end of the scheme are restricted to a maximum of Subgrade 3b, Subgrade 3a and Grade 2 by climatic limitations. The soil Grades distribution

across the scheme and receptor value (sensitivity) are summarised in Table 9-29: Soil resources - Cross Lanes to Rokeby.

Table 9-29: Soil resources - Cross Lanes to Rokeby

Soil grades present within the Order Limits	Permanent land take within the Order Limits	Temporary land take within the Order Limits	Total area of each grade within Order Limits	*DMRB LA 109*[1] Receptor Value (Sensitivity)
Grade 1	n/a	n/a	None identified	n/a
Grade 2	n/a	n/a	None identified	n/a
Grade 3 subgrade 3a	n/a	n/a	None identified	n/a
Grade 3 subgrade 3b	5.9ha	1.0ha	6.9ha (11%)	Medium
Grade 4	n/a	n/a	None identified	n/a
Grade 5	n/a	n/a	None identified	n/a
Urban	15.5ha	1.6ha	17.1ha (27%)	Negligible
Not surveyed	31.7ha	8.6ha	40.3ha (63%)	n/a

9.7.153 Based on the limited ALC survey information no soil of Agricultural Land Classification Grades 1, 2 or 3a (BMV land) was recorded in the Order Limits of the Cross Lanes to Rokeby scheme Order Limits.

Stephen Bank to Carkin Moor

Geological context

9.7.154 The published geological maps show that Stephen Bank to Carkin Moor is underlain by Made Ground, followed by natural superficial deposits comprising predominantly of Glacial Till. Pockets of Alluvium and Glaciofluvial deposits are anticipated to the south-west. The mapped bedrock below the scheme comprises of the Alston Formation, Four Fathom Limestone Member, the Alston Formation (sandstone) and the Five Yard Limestone Member.

Geodiversity sites

9.7.155 No geodiversity sites have been identified in the study area.

Contamination sources

9.7.156 Following screening of these sites, a number of potentially contaminative sites have been identified which could be impacted by the Project, including disused quarries, farms, tanks and an anaerobic digestion facility, see ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

Contamination receptors

9.7.157 A number of potential receptors to contamination have been identified in the study area. These include residents, secondary A aquifers and numerous surface watercourses, see ES Appendix 9.3: Geology and

Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). Further information on groundwater and surface water receptors is provided in ES Chapter 14: Road Drainage and the Water Environment.

9.7.158 There are no designated sites within the study area.

Ground investigation key findings

9.7.159 A programme of ground investigation took place between 22 February 2021 and 16 March 2021. Key findings relevant to this chapter are presented below. The full details of the ground investigation and findings are reported in GIR Package C-Stephen Bank to Carkin Moor and A1(M) Junction 53 Scotch Corner ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

9.7.160 The GI in this study area comprised 25 cable percussion boreholes to a maximum depth of 17.00m, nine cable percussion boreholes extended by rotary coring to a maximum depth of 25.60m, three windowless sampling boreholes to a maximum depth of 6.65m and 45 machine-excavated trial pits to a maximum depth of 6.00m.

Encountered ground conditions

9.7.161 A summary of the encountered ground conditions based on the ground investigation within the study area is provided in Table 9-30: Summary of proven geology and ground conditions: Stephen Bank to Carkin Moor.

Table 9-30: Summary of proven geology and ground conditions: Stephen Bank to Carkin Moor

Strata	Proven depth range (mbgl)	Description
Superficial		
Topsoil	0.00-0.50	Soft dark brown sandy slightly gravelly clay with rootlets.
Made Ground Cohesive and Granular	0.20-2.00	Very clayey slightly gravelly sand, or slightly sandy slightly gravelly clay.
Glacial Deposits-Cohesive	0.20-6.00	Firm slightly sandy slightly gravelly clay with medium cobble content and occasionally included boulders.
Glacial Deposits-Granular	2.20-5.50	Bands of clayey very sandy gravel or gravelly sand interbedded within the cohesive deposits.
Bedrock		
Mudstone (Alston Formation)	1.80-10.50	Extremely weak, distinctly weathered grey mudstone, often recovered as gravel.
Limestone (Alston Formation)	0.80-22.50	Fine grained grey packstone with thick, wavy beds and mudstone partings, becoming more argillaceous towards the top.
Sandstone (Alston Formation)	0.80-10.00	Weak and partially weathered and interlaminated with mudstone at depth.

Encountered groundwater conditions

9.7.162 Groundwater was observed in a number of exploratory holes with a response zone depth range of 1.00 to 16.00m bgl. Groundwater strikes were generally recorded at or just below the mudstone rockhead level. Details are presented on the borehole logs in GIR Package B-M6 Junction 40 to Kemplay Bank and Penrith to Temple Sowerby ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

9.7.163 LiDAR and aerial photography identified fifteen enclosed depressions located within 2km of this alignment upgrade section. The walkover identified four of these enclosed depressions and one spring, but all depressions were confirmed as not karst. A small number of karst features were identified on the Four Fathom Limestone Member, but these features are typical of small-scale karst related to local fracturing or weathered zones that facilitate groundwater flow. Both the Four Fathom Limestone Member and Alston Formation were categorised as a low karst risk. A low karst risk has been concluded for the Five Yard Limestone Member. This assessment was made based on the thin nature of the member but also due to the low occurrence of karst features in the area of the alignment. Those features identified are generally shallow features. There are no recorded features on the Five Yard Limestone.

GI chemical testing overview

9.7.164 Geo-environmental testing of Made Ground and natural strata has been carried out within the Stephen Bank to Carkin Moor study area. Full details of which are given in the GIR Package C-Stephen Bank to Carkin Moor and A1(M) Junction 53 Scotch Corner ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4) and key findings are summarised below.

9.7.165 Groundwater and surface water samples were also collected for analysis.

9.7.166 Visual and olfactory indicators of potential contamination during the ground investigation comprised of one observation of ash within Made Ground at one exploratory location (BH SBC006 27m north of A66 near Anaerobic digestion facility to the west). Table 9-31: Summary of chemical analysis of Stephen Bank to Carkin Moor samples presents a summary of the GI sampling, analysis along with the findings of preliminary assessment.

Table 9-31: Summary of chemical analysis of Stephen Bank to Carkin Moor samples

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
Soil	93 (comprising 7 Made Ground, 40 Topsoil and 46 Glacial Deposit)	Primary metals and metalloids, inorganics, CN/Phenol analysis, TPH CWG, BTEX, speciated PAHs and WAC testing	Benzo(a) anthracene, benzo(a) pyrene, benzo(b) fluoranthene, and chrysene were recorded as exceeding the Public Open Space Park (POSPark) assessment criteria. (Samples taken from Made Ground).	WS SBC004 sampled at 0.3m bgl (located on A66, 131m north of old quarries)-PAHs	The exceedances are likely associated with the macadam which was recorded within the Made Ground. The PAHs are therefore likely bound within solid material and relatively immobile.
Soils -Asbestos	67 (comprising Topsoil, Made Ground, and natural superficial deposits)	Asbestos (presence and identification and quantification)	No asbestos was detected within samples examined in the laboratory. No asbestos containing materials were observed during ground investigation.	-	-
Soils - Leachate	29 (comprising Topsoil, Made Ground, and natural superficial deposits)	Electrical Conductivity, Total Dissolved Solids, Chloride, Fluoride, Sulphate, DOC, Metals, Phenols	Molybdenum (6 samples) and Copper (5 samples) were recorded as exceedances screened against CWRA using the lowest available WQS (i.e., DWS or EQS) of Tier 1 and 2	One of the molybdenum and three of the copper exceedances were in made ground, with the remainder in natural soils.	Leachate testing identified exceedances of copper and molybdenum

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
			Soil leachate tests do not simulate in-situ conditions and concentrations from soil leachate tests are considered conservative. Due to the incorporation of positive drainage and hardstanding by the proposed scheme, the exceedances have not been progressed to a Tier 2 assessment but are qualitatively assessed.		
Groundwater	3	Metals and metalloids, major ions, ammoniacal nitrogen, total suspended solids, oxygen demand, TPHCWG, BTEX, Speciated PAHs, Phenols and Cyanides	Majority of exceedances were for PAHs and some exceedances were found for heavy metals. Therefore, these were progressed to Tier 2 assessment. There are 16 contaminants of concern exceedances of Tier 2 criteria.	BH SBC006 sampled at 3.74m bgl (located 27m north of A66 near Anaerobic digestion facility to the west), BH SBC008 sampled at 1.10m bgl (located 25m north of A66), and BH SBC032A sampled at 6.09m bgl (located 12m south of A66)-PAHs and metals	A number of exceedances were recorded above the tier 2 assessment criteria in groundwater, which include metals and metalloids, aromatic chained hydrocarbons and PAHs. The concentrations of the contaminants of concern observed within soils are unlikely to be a significant source of the recorded groundwater

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
					contamination, with no significant sources of potential contamination identified in the vicinity of the scheme within the PSSR. It is likely that groundwater within the wider region is impacted and migrating beneath the proposed scheme extents.
Surface water (unnamed tributary of River Greta)	2	Metals and metalloids, major ions, ammoniacal nitrogen, total suspended solids, oxygen demand, TPHCWG, BTEX, Speciated PAHs, Phenols and Cyanides	Marginal exceedances of the Tier 1 surface water criteria for copper, and ammoniacal nitrogen. Therefore, these were progressed to Tier 2 assessment. Marginal exceedances of Tier 2 criteria for copper, and ammoniacal nitrogen.	SW SBC002-copper, and ammoniacal nitrogen. SW SBC001-copper	The exceedances observed within surface water are significantly less than those in groundwater, suggesting that groundwater is not currently adversely affecting surface waters, hence, exceedances are likely to be due to general diffuse pollution, attributed to the possible use of pesticides and/or herbicides on land adjacent to the scheme.

Ground gas

9.7.167 The desk study information did not identify any potentially significant sources of ground gas. During the GI Made Ground was sporadically encountered across the route at 15 exploratory locations and typically ranged between 0.15m and 2.0m in thickness. No organic material or degradable content was observed during the investigation and the average total organic carbon (TOC) for Made Ground was measured at 1.8%. Made Ground at the site is considered to have limited gassing potential and there is negligible risk from ground gas. Therefore, no ground gas monitoring was undertaken for this scheme.

Summary

9.7.168 The human health and controlled waters risk assessments, carried out and detailed in the GIR Package C-Stephen Bank to Carkin Moor and A1(M) Junction 53 Scotch Corner ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4), indicates there is low risk from land affected by contamination within the Stephen Bank to Carkin Moor study area. The chemical results and subsequent quantitative risk assessment showed that there is low risk to human health receptors within the scheme. The controlled waters risk assessment indicates a number of exceedances of Tier 1 and Tier 2, likely to be as a result of impacted and migrating groundwater within the wider region as no significant sources of potential contamination were identified within the scheme. Surface water exceedances were less than those in groundwater presenting low risk to controlled waters. Overall, recorded exceedances within the study area were not located within zone 1 of the route alignment.

Soils

9.7.169 Across the majority of the Stephen Bank to Carkin Moor scheme the published soil is mapped as Wick 1 Association. This is typically described as having deep well drained coarse loamy soils and are well to moderately well drained and in this part of the country fall into WC 1 or 2 and so into ALC Grade 2.

9.7.170 To the far east of Stephen Bank to Carkin Moor the soils are mapped as Brickfield 2 Association. These soils typically consist of slowly permeable, seasonally waterlogged fine loamy soils and largely fall into WC 4 when undrained (ALC Grade 3b or 4) and WC 3 with artificial drainage (ALC Grade 3a/b).

9.7.171 The Stephen Bank to Carkin Moor survey was carried out between 7 February and 28 February 2022 and comprised 68 number of survey locations. Access was not granted for survey of a further 5 number locations due to livestock in the fields at the time. A sufficient number of sample locations were accessed to enable a land classification value.

9.7.172 The soils on this scheme typically have very dark or dark grey, brown medium or heavy clay loam topsoil to 28-30cm depth over light grey and yellow heavy clay loam or clay subsoil with ochreous, grey and yellow mottles to 100cm plus depth. The soils are poorly drained. The soil

Grades distribution across the scheme and receptor value (sensitivity) are summarised in Table 9-32: Soil resources - Stephen Bank to Carkin Moor.

Table 9-32: Soil resources - Stephen Bank to Carkin Moor

Soil grades present within the Order Limits	Permanent land take within the Order Limits	Temporary land take within the Order Limits	Total area of soil within Order Limits	*DMRB LA 109*[1] Receptor Value (Sensitivity)
Grade 1	n/a	n/a	None identified	n/a
Grade 2	n/a	n/a	None identified	n/a
Grade 3 subgrade 3a	6.6ha	1.2ha	7.9ha (8%)	High
Grade 3 subgrade 3b	27.7ha	12.2ha	39.9ha (42%)	Medium
Grade 4	14.1ha	8.7ha	22.8ha (24%)	Low
Grade 5	n/a	n/a	None identified	n/a
Non-agricultural	3.2ha	0.14ha	3.4 ha (4%)	Negligible
Urban	18.2ha	0.7ha	18.9ha (20%)	Negligible
Not surveyed	0ha	1.2ha	1.2ha (1.3%)	Negligible

9.7.173 The ALC survey recorded <10% of the area surveyed is formed of soil of Agricultural Land Classification Grades 3a (BMV land) in the Stephen Bank to Carkin Moor Order Limits. 6.6ha of Grade 3a BMV land will be with the permanent land take.1.2ha of Grade 3a BMV land will be within the area required temporary construction land take.

A1(M) Junction 53 Scotch Corner

Geological context

9.7.174 The published geological maps for Scotch Corner indicate the scheme is underlain by Made Ground, followed by natural superficial deposits comprising predominantly of Glacial Till. An area just south of the A1 Junction with the A66 is not shown to be underlain by any superficial deposits; as such, bedrock is anticipated to be shallow in this area of Scotch Corner. The mapped bedrock below the scheme comprises Four Fathom Limestone Member.

Geodiversity sites

9.7.175 No geodiversity sites have been identified in the study area.

Contamination sources

9.7.176 The study area is located within a predominantly agricultural area. The proposed works in this area are predominantly at-grade and largely within the existing highway boundary, therefore no potential contamination sources were identified as a result of the screening process.

Contamination receptors

9.7.177 Potential receptors to contamination have been identified in the study area. These include residents, Secondary A aquifers and abstractions and Ludburn Beck surface watercourse, see ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). Further information on groundwater and surface water receptors is provided in Chapter 14: Road Drainage and the Water Environment.

9.7.178 There are no designated sites within the study area.

Ground Investigation

9.7.179 A programme of ground investigation took place between 22 February 2021 and 16 March 2021. Key findings relevant to this chapter are presented below. The full details of the ground investigation and findings are reported in GIR Package C-Stephen Bank to Carkin Moor and A1(M) Junction 53 Scotch Corner ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

9.7.180 The GI comprised two windowless sampling boreholes to a maximum depth of 6.65m and four hand-dug trial pits to a maximum depth of 1.2m. Natural ground was not encountered in the exploratory hole locations.

Encountered ground conditions

9.7.181 A summary of the encountered ground conditions during the ground investigation within the study area are provided in Table 9-33: Summary of proven geology and ground conditions: A1(M) J53 Scotch Corner.

Table 9-33: Summary of proven geology and ground conditions: A1(M) J53 Scotch Corner

Strata	Proven maximum depth (m bgl)	Description
Superficial		
Made Ground	6.65	Soft black, brown slightly sandy gravelly CLAY with frequent rootlets including sandstone, tarmac, ceramic tile, plastic fragments and clinker with reworked clayey SANDs, sands and Gravels and soft to firm CLAYs below

Encountered groundwater conditions

9.7.182 No groundwater strikes were encountered during the investigation. Details are presented on the borehole logs in GIR Package B-M6 Junction 40 to Kemplay Bank and Penrith to Temple Sowerby ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4).

9.7.183 A1(M) J53 Scotch Corner was not included within the karst assessment. Although the Four Fathoms Limestone Member was not considered within the original risk assessment for the scheme, it was assessed for other schemes as having a low karst risk and will not be considered further for this scheme.

GI chemical testing overview

9.7.184 Geo-environmental testing of soils has been carried out within the A1(M) Junction 53 Scotch Corner scheme. Full details of which are given in the GIR Package C-Stephen Bank to Carkin Moor and A1(M) Junction 53 Scotch Corner ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4) and key findings are summarised below.

9.7.185 Visual and olfactory indicators of potential contamination during the ground investigation predominantly comprised of macadam, roadstone and clinkers found locally within Made Ground. There is also olfactory evidence of hydrocarbon odour found within Made Ground (WS A1SC005 located 33m south of Junction 53 and WS A1SC006 located 22m east of A6108 near Junction 53) which is considered to be attributed to the composition of the Made Ground.

9.7.186 Table 9-34: Summary of chemical analysis of A1(M) Junction 53 Scotch Corner presents a summary of the GI sampling, analysis along with the findings of preliminary assessment.

Table 9-34: Summary of chemical analysis of A1(M) Junction 53 Scotch Corner

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
Soil	11 (comprising Made Ground)	Primary metals and metalloids, inorganics, CN/Phenol analysis, TPH CWG, BTEX, speciated PAHs and WAC testing	Exceedances of benzo(a) pyrene, and dibenz(a,h) anthracene over the POSPark assessment criteria.	WS A1SC006 Made Ground/Topsoil sampled at 1.00m bgl (located 22m east of A6108 near Junction 53)	Likely associated with the mild hydrocarbon odour and Macadam, roadstone and clinker present in Made Ground at this location.
Soils - Asbestos	11 (comprising Topsoil, Made Ground, and natural superficial deposits)	Asbestos (presence and identification and quantification)	No asbestos was detected within samples examined in the laboratory. No asbestos containing materials were observed during ground investigation.	-	-
Soils - Leachate	3 (comprising Topsoil, Made Ground, and natural superficial deposits)	Electrical Conductivity, Total Dissolved Solids, Chloride, Fluoride, Sulphate, DOC, Metals, Phenols	Exceedance of copper and exceedance of zinc were recorded as exceedances screened against CWRA using the lowest available WQS (i.e., DWS or EQS) of Tier 1 and 2. Soil leachate tests do not simulate in-situ conditions and concentrations from soil leachate tests are considered conservative. Due to the incorporation of positive drainage and hardstanding by the proposed scheme, the	WS A1SC006 Topsoil sampled at 0.20m bgl (located 22m east of A6108 near Junction 53)-copper, and zinc	Leachate testing identified exceedances of zinc and copper which reduced with depth with no visual evidence of free product identified.

Sample type	No. of samples	Analysis suite	Exceedances	Location of exceedances	Qualitative assessment
			exceedances have not been progressed to a Tier 2 assessment but are qualitatively assessed		
Groundwater	-	-	No groundwater was encountered during the site works. However, groundwater is anticipated to be present at greater depths unlikely to interact with the scheme.	-	-
Surface water	-	-	No surface water courses identified in the immediate vicinity of the proposed works (adjacent and/or <50m).	-	-

Ground gas

9.7.187 No potentially significant sources of ground gas were identified within the baseline information. During the ground investigation Made Ground was sporadically encountered at six exploratory locations. No degradable content was observed during the investigation and, whilst a significant thickness of Made Ground was encountered, the average TOC for Made Ground is 1.2%. Made Ground at the site is considered to have limited gassing potential. Therefore, no ground gas monitoring has been undertaken for this scheme.

Summary

9.7.188 The human health and controlled waters risk assessments, carried out and detailed in in the GIR Package C-Stephen Bank to Carkin Moor and A1(M) Junction 53 Scotch Corner ES Appendix 9.2: Ground Investigation Reports (Application Document 3.4), indicates there is low risk from land affected by contamination within A1(M) Junction 53 Scotch Corner study area. The chemical results and subsequent quantitative risk assessment showed that there is low risk to human health receptors within the scheme. No groundwater was encountered, and no surface water courses identified in the immediate vicinity of the scheme. Overall, recorded exceedances within the study area were not located within zone 1 of the route alignment.

Soils

9.7.189 The A1(M) Junction 53 Scotch Corner scheme was not included in this A66 ALC survey due to the limited proposed works in this area and the existing nature of the soil environment.. The A1(M) Junction 53 Scotch Corner scheme will widen the existing Middleton Tyas Lane approach at Scotch Corner roundabout from one lane to two lanes.

9.7.190 An additional lane will also be provided on the northern bridge of the circulatory carriageway, increasing the provision in this area to three lanes. The Project at this location is largely within existing highway environment. The land affected by this scheme is non-agricultural and urban with negligible value and very little potential to return to agriculture.

Conceptual site model of the Project

9.7.191 A conceptual site model of the Project has been developed to identify the potential contaminant linkages. The Project's topography, geology, hydrogeology and hydrology are the main factors that influence the way in which potential contaminants in the soil or groundwater can be transported on or off site, as well as how contaminants can affect different sensitive receptors. This section sets out a summary of potential receptors, followed by potential contamination sources. Finally, pathways linking any sources to identified receptors are then described.

9.7.192 Detailed conceptual sites models have been developed for potentially contaminated sites which have been identified for detailed risk

assessment. The detailed conceptual site model for each scheme is presented in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

Receptors

9.7.193 Identification of the site-specific receptors is based on the Project's proposed land use as well as environmental setting of the study area. Table 9-35: Summary of potentially sensitive receptors presents the identified potentially sensitive receptors considered within the assessment. The detailed conceptual site model identifies the receptors present for each scheme and is presented in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models.

Table 9-35: Summary of potentially sensitive receptors (based on Table 3.11 of *DMRB LA 109*[1]*)*

Value/ sensitivity	Aspect	Description(as defined in DMRB LA 109[1])	Identified receptors within the study area
Very High	Geology	International designated sites of geological value (e.g., UNESCO World Heritage Sites).	North Pennies AONB/ UNESCO Global Geopark Appleby to Brough (scheme 6) and Bowes Bypass (scheme 7)
	Soils	Soils directly supporting an EU designated site (e.g., SAC, SPA, Ramsar) ALC grade 1 & 2	No ALC Grade 1 soils identified within the Order Limits; ALC Grade 2 identified: M6 Junction 40 to Kemblay Bank, Penrith to Temple Sowerby and Temple Sowerby to Appleby.
	Contamination: Human health	Very sensitive land use such as residential, allotments	Residential properties located throughout the Project study area
	Contamination: surface water	Nationally significant attributes- Watercourse having a Water Framework Directive (WFD) classification shown in a River Basin Management Plan 1 (RBMP) and a Q95 ≥ 1.0 m3/s. Species or site protected/designated under EC or UK legislation e.g., special area of conservation (SAC), site of special scientific interest (SSSI), special protection area (SPA).	Moor Beck, Manyfold Beck, Beck, Broom Rigg Beck, Myers SAC River Eden, SSSI River Eamont, SSSI Trout Beck, Ludburn Beck

Value/ sensitivity	Aspect	Description(as defined in DMRB LA 109[1])	Identified receptors within the study area
	Contamination: groundwater	Nationally significant attributes- Principal aquifer, providing a regionally important resource and/or supporting a site protected under EC and UK legislation. Groundwater that locally supports a groundwater dependent terrestrial ecosystem (GWDTE). Inner source protection zone (SPZ1).	Penrith Sandstone throughout the Project study area.
High	Geology	Rare and of national importance with little potential for replacement (e.g., geological SSSI). Geology meeting national designation citation criteria which is not designated as such.	None identified.
	Soils	Soils directly supporting a UK designated site (e.g., SSSI) and or ALC grade 3a	Soils directly supporting a UK designated site (e.g., the River Eden SAC and the River Eden Tributaries SSSI at Penrith to Temple Sowerby. ALC Grade 3a: M6 Junction 40 to Kemblay Bank, Penrith to Temple Sowerby, Temple Sowerby to Appleby, Appleby to Brough, Stephen Bank to Carkin Moor
	Contamination: Human health	High sensitivity land use such as public open space.	Cricket Ground Penrith to Temple Sowerby (scheme 3)
	Contamination: surface water	Locally significant attributes- Watercourse having a WFD classification shown in a RBMP and Q95 <1.0m3/s. Species protected under EC or UK legislation	None identified
	Contamination: Groundwater	Principal or Secondary A aquifer which provided important local resources or support a river ecosystem.	Secondary A aquifer, the Carboniferous strata comprises of the Stainmore Formation (mudstone, siltstone and sandstone),

Value/ sensitivity	Aspect	Description(as defined in DMRB LA 109[1])	Identified receptors within the study area
		Groundwater supports a GWDTE SPZ2	the Great Limestone Member (limestone member of the Alston Formation), the Alston Formation (limestone, sandstone, siltstone and mudstone) and Four Fathom Limestone Member (limestone member of the Alston Formation).
Medium	Geology	Regionally Important Geological Sites with limited potential for replacement (e.g., RIGS). Geology meeting regional designation citation criteria which is not designated as such	None identified
	Soils	Soils supporting non-statutory designated sites (e .g. Local Nature Reserves (LNR), LGS, Sites of Nature Conservation importance (SNCIs)) and or ALC grade 3b	ALC Grade 3b identified M6 Junction 40 to Kemblay Bank, Temple Sowerby to Appleby, Appleby to Brough, Bowes Bypass, Cross Lanes to Rokeby, Stephen Bank to Carkin Moor
	Contamination: Human health	Medium sensitivity land use such as commercial or industrial.	Users of commercial properties and industrial areas located throughout the study area
	Contamination: Surface water	Of moderate quality or rarirty- Watercourse not having a WFD classification shown in RBMP and a Q95 > 0.001 m3/s.	Unnamed water courses, ordinary watercourses, springs Lowgill Beck (watercourses), Tutta Beck
	Contamination: Groundwater	Aquifer providing water for agricultural or industrial use with limited connection to surface water. SPZ3	Secondary B aquifer- Eden Shale Formation. M6 Junction 40 to Kemplay bank: Abstraction well 277600644 Temple Sowerby to Appleby Agricultural abstraction well (Licence number: 2776003013) Agricultural abstraction well (Licence number: 2776003012/R01) Stephen Bank to Carkin Moor, Blackhill Farm

Value/ sensitivity	Aspect	Description(as defined in DMRB LA 109[1])	Identified receptors within the study area
			abstraction well (no licence number)
Low	Geology	Geology of local importance / interest with potential for replacement (e.g., non designated geological exposures, former quarries / mining sites).	None identified
	Soils	ALC grade 4 & 5 and or Soils supporting non-designated notable or priority habitats	ALC Grade 4: Temple Sowerby to Appleby, Appleby to Brough Stephen Bank to Carkin Moor ALC Grade 5: Appleby to Brough
	Contamination: Human health	Low sensitivity land use such as highways and rail.	Local road network.
	Contamination: Surface water	Lower quality- Watercourse not having a WFD classification shown in RBMP and a Q95 ≤ 0.001 m3/s.	Ordinary watercourse
	Contamination: Groundwater	Lower quality- Unproductive strata.	
Negligible	Geology	No geological exposures, little / no local interest.	None identified.
	Soils	Previously developed land formerly in 'hard uses' with little potential to return to agriculture	Urban soils identified in all schemes
	Contamination: Human health	Undeveloped surplus land / no sensitive land use proposed.	Undeveloped field.
	Contamination: Surface water	*Not included in Table 3.70 of DMRB LA 113 Road drainage and the water environment (DMRB LA 113)* (Highways England (now National Highways), 2020)[44]	Not applicable.
	Contamination: Groundwater	Not included in Table 3.70 of *DMRB LA 113*[44]	Not applicable.

Potential sources of contamination

9.7.194 The potential sources of land contamination within the study area are identified in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). An assessment was carried out based on the proximity, land use and

[44] Highways England (now National Highways) (2020) Design Manual for Roads and Bridges LA 113 Road drainage and the water environmente

construction design element as described in section 9.4 and an impact score has been applied.

9.7.195 Potentially contaminated sites with an impact score of two or below were assessed as posing a low risk to the receptors and have been scoped out of further assessment. The sites rated two and below are given in Table 1 4: Summary of sites scoped in for Detailed Risk Assessment based on baseline Impact score 1 and 2 of ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

9.7.196 Potentially contaminated sites which scored an impact score rating of three or above were considered moderate to high contamination risk to receptors and were subject to further assessment. The sites rated three and above are given in Table 1 5: Summary of sites scoped in for Detailed Risk Assessment based on baseline Impact score 3, 4 and 5 of ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

9.7.197 The potentially contaminated sites, with an impact score of three or above, identified within the study area have been grouped by land use as below:

- Ministry of Defence Land (MoD)
- Petrol filling station
- Farms
- Railway sites
- Landfill sites
- Quarries and infilled sites
- Light industrial sites
- Cemetery sites and
- Foot and Mouth Disease burial sites.

9.7.198 A detailed conceptual site model and risk assessment has been carried out for each of the groups and is presented in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

Potential pathway

9.7.199 The human health exposure pathways that are considered viable based on the proposed highways end use, but also accounting for neighbouring properties and people during the operation and construction, are identified below:

- Dermal contact with soil, dust and groundwater
- Ingestion of soil, dust and groundwater
- Inhalation of dust
- Inhalation of vapours (from soils and groundwater)
- Inhalation of ground-gas in confined spaces.

9.7.200 The controlled waters (surface water and groundwater) pathways considered viable are as follows:

- Mobilisation of soluble contaminants exposed during construction works
- Vertical and lateral migration of leachate through the unsaturated zone to groundwater
- Vertical and lateral groundwater migration
- Surface water run-off.

9.7.201 The built environment (underground structures and buried services) pathways that are considered viable are as follows:

- Ingress and/or accumulation of ground gas/vapours
- Direct contact of ground with in-ground structures: sulphate attack on concrete foundations and/or permeation of hydrocarbons through plastic potable water supply pipes.

9.7.202 The natural environment (ecological designations) pathways that are considered viable are as follows:

- Migration of dust and direct contact with statutory sites for nature conservation

Future baseline

9.7.203 As set out in Chapter 4: Environmental Assessment Methodology (Application Document 3.2), the 'Do-Minimum' and 'Do-Something' scenarios have been set out, with the 'Do-Minimum' scenario representing the future baseline without the Project (i.e. the existing road, only subject to ongoing maintenance). The future baseline considers any likely change in conditions that will occur in the absence of the Project - for this chapter that is mainly climate change impacts.

9.7.204 There are two future baseline years that the Project considers:

- Opening year - when the scheme is operational (i.e. open to traffic) is 2029.
- Design year/future year - a future year scenario 15 years after the opening year when mitigation measures are likely to have achieved their desired outcome, (i.e. future/design year) is 2044.

9.7.205 The in-combination climate change assessment has used a future climate baseline that is based on representative concentration pathway 8.5 (RCP 8.5) of the UK climate change 2018 projections (UKCP18). This future climate baseline is presented in Chapter 7: Climate(Application Document 3.2).

9.7.206 The predicted rise in UK average temperature will lead to more rain falling in intense storms and increased.summer temperatures . Such events will lead to increased drought and increased soil erosion.

9.7.207 Changes to soil temperature and moisture levels will increase pressures on farming,due to reduced soil fertility and the loss of high-quality agricultural soils and BMV land. Soils will become increasingly less fertile, damaging wildlife and the ecosystem services that soils provide.

9.7.208 Increased summer temperatures will lead to physical impacts to soils, such as dessication cracks and settlement.

9.7.209 The predicted climatic changes have the potential to impact the mobility and migration of contaminant within the ground and groundwater.The potential combined effects relating to geology and contamination and future climate change for the Project include, but not limited to:

- the risk of contamination migration through changes in temperature and atmospheric pressure
- the risk of contamination migration through fluctuating groundwater levels
- increased erosion of geology and soils (extremes in temperatures, increased rainfall intensity) and
-

9.7.210 The future baseline conditions, at time of operational opening in 2029, (i.e .seven years time) are not expected to alter significantly from current baseline conditions. Potential changes to the geology and soils receptors in the future baseline will not be noticeable and the impacts are unlikley to be different to those identified in this chapter.

9.8 Potential impacts

9.8.1 Based on the Project design and associated construction activities, the Project has the potential to impact upon geology and soil and impact the disturbance of contaminated soils or groundwater during both construction and operation and an assessment has been made using the DMRB LA 109[1]assessment methodology and DMRB LA 104 significance criteria.

9.8.2 The design of the Project, including any embedded mitigation measures that have been incorporated, are described in Chapter 2: The Project. Any key aspects of the design and embedded mitigation are also referenced in this section, where they are directly applicable to the geology and soils assessment.

9.8.3 Potential impacts of the Project are described in this section prior to the implementation of the essential mitigation described in section 9.9: Essential mitigation and enhancement measures. The residual effects of the Project, considering this essential mitigation, are then described in section 9.10: Assessment of likely significant effects.

Construction

Contaminated soils and groundwater

9.8.4 In the event of disturbance of contaminated soils or groundwater during construction, there is a potential for human, ecological or controlled water receptors to be affected, and for ground conditions to impact the design of the proposed scheme.

9.8.5 Potential impacts for contaminated soils and groundwater:

- Mobilising existing contaminants in soil and groundwater as a result of exposure following ground disturbance and de-watering during construction

- Increasing the potential for contaminants in unsaturated soils to leach to groundwater in open excavations during construction
- Increasing the potential for contaminated surface run-off to migrate to surface water and groundwater receptors
- Creating preferential pathways for the migration of soil contamination and ground gases through ground disturbance or piling
- Introducing new human health receptors such as site staff/construction workers during construction
- Introduction of new sources of contamination, such as fuels and oils used in construction plant; impact on the water environment is considered in Chapter 14: Road Drainage and the Water Environment
- Removal or remediation of any areas of contaminated soils identified
- Unexpected ground conditions / exposure of area of unexpected contamination.

Geodiversity

9.8.6 Appleby to Brough and Bowes Bypass are situated partly within parts of the North Pennines AONB/ UNESCO Global Geopark. Potential impacts could arise from land disturbance within the designated UNESCO Global Geopark area during construction, for example, if any existing exposures are covered over, or there are changes to land accessibility that temporarily impair the enjoyment of the Geopark. In addition, there are potential benefits to creating cuttings and new exposures which allow interested parties, in the geological community access, to view the geological exposure for the purpose of benefitting scientific studies.

Soils

9.8.7 Soil is a finite resource that fulfils many important functions and services for society in addition to the production of food and fibre, and it is recognised in paragraph 174 of the NPPF[6] that soil resources should be conserved and enhanced. The NPSNN policy 5.168 states that the economic and other benefits of the best and most versatile agricultural land (BMV) should be taken into account. Where significant development on agricultural land is necessary, the Project should seek to use areas of poorer quality land in preference to those of a higher quality. Given the rural location of the Project the potential to avoid and mitigate adverse impacts is limited.

9.8.8 During construction there is potential for both temporary (minor impacts) and permanent (major to moderate) impacts to soils and/or reduction of one or more soil function(s) and restriction to current or approved future use (e.g. through degradation, compaction, erosion of soil resource) as defined in DMRB LA 109[1].

9.8.9 There is potential for soils outside of the land take areas to be affected temporarily by construction works, through dust and runoff waters.

9.8.10 During the construction phase there is potential to permanently impact soils through:

- the loss of potentially valuable soil and risk of long-term damage to soil structure, through uncontrolled trafficking of land and soil by heavy machinery;
- damage to, and loss of, topsoil could occur through poorly managed stockpiling or possibly by poor work causing mixing of topsoil subsoil and other materials during stockpile placement or removal
- Degradation of topsoil due to compaction in storage and / or when stockpiled when wet in particular when stockpiled in the medium-to-long-term

9.8.11 Permanent loss through sealing agricultural land, for example with hard standing and highway infrastructure. The permanent paving over of agricultural land for road construction means soil functions, including food and fibre production, the potential for supporting forestry, woodland and species rich vegetation, ability to sequester carbon and store water will be lost.

9.8.12 The construction of the Project will result in the permanent loss of approximately 140 ha of BMV agricultural land. No ALC Grade 1 soil was identified in the Order Limits. The loss will mainly be of very good (ALC Grade 2) and good (ALC Grade 3a). Approximately 80 ha of Grade 2 soil and approximately 64 ha of Grade 3a will be permanently lost across the entire Project.

9.8.13 ALC Grade 2 soil is defined as of very high receptor value, ALC Grade 3a is defined as of high receptor value. The largest area of BMV land permanently lost will be in Temple Sowerby to Appleby, with over 70ha of the permanent land lake within this area. This is assessed as a major magnitude of impact.

9.8.14 ALC Grade 3b is of moderate agricultural land quality and approximately 140ha will be permanently lost across the Project. Permanent land take in Temple Sowerby to Appleby, Appleby to Brough and Stephen Bank to Carkin Moor all exceed 20ha. This is assessed as a major magnitude of impact.

9.8.15 A limited number of poor (ALC Grade 4) and very poor (ALC Grade 5) agricultural land will also be lost, approximately 30ha (major magnitude of impact) and 3.4ha (moderate magnitude of impact) respectively Project wide.

9.8.16 Where there is likely to be physical removal or permanent sealing of over 20ha of agricultural land this is assessed as a major magnitude of impact.

9.8.17 Where there is likely to be physical removal or permanent sealing of between 1ha and 20ha of agricultural land, or permanent loss/ reduction of one of or more soil functions this is assessed as a moderate magnitude of impact.

9.8.18 Table 9-36: Route wide land grade Permanent loss shows the soil loss in hectares for each scheme, and overall total route wide.

9.8.19 Potential impacts associated with temporary dewatering, if required and impacts to groundwater levels due to drawn down during construction,

are assessed in Chapter 14: Road Drainage and the Water Environment.

Table 9-36: Route wide land grade Permanent loss

Scheme	Grade 1	Grade 2	Grade 3a	Grade 3b	Grade 4	Grade 5	Non-agricultural	Urban
M6 Junction 40 to Kemplay Bank	0	4.7	1	0	0	0	1.5	26.3
Penrith to Temple Sowerby	0	30.5	4.2	0	0	0	1.1	2.1
Temple Sowerby to Appleby	0	43.9	27.2	35.9	0.4	0	6.4	27.9
Appleby to Brough	0	0	24.8	49.1	15	3.4	13.4	19.2
Bowes Bypass	0	0	0	19.5	0	0	0	18.6
Cross Lanes to Rokeby	0	0	0	5.9	0	0	0	15.5
Stephen Bank to Carkin Moor	0	0	6.6	27.7	14.1	0	3.2	18.2
Total permanent loss (ha)	0	79.1	63.8	138.1	29.5	3.4	25.6	127.8

Table 9-37: Route wide soil grade Temporary loss

Scheme	Grade 1	Grade 2	Grade 3a	Grade 3b	Grade 4	Grade 5	Non-agricultural	Urban
M6 Junction 40 to Kemplay Bank	0	5.6	1.6	0	0	0	0.1	3.6
Penrith to Temple Sowerby	0	34.8	2.5	0	0	0	1	0.1
Temple Sowerby to Appleby	0	28.8	19	10	0	0	0.6	3.1
Appleby to Brough	0	0	19.1	15.9	6.6	2.4	0.5	1.7
Bowes Bypass	0	0	0	15.9	0	0	0	18.6
Cross Lanes to Rokeby	0	0	0	1	0	0	0	1.6

Scheme	Grade 1	Grade 2	Grade 3a	Grade 3b	Grade 4	Grade 5	Non-argicultural	Urban
Stephen Bank to Carkin Moor	0	0	1.2	12.2	8.7	0	0.14	0.7
Total Temporay loss (ha)	0	69.2	43.4	55	15.3	2.4	2.34	29.4

Operation

Contaminated soils and groundwater

9.8.20 During the operational stage of the Project, conditions may have altered from the baseline as a result of,:

- Introduction of road users operational maintenance staff and road infrastructure as new receptors
- Revised road drainage and discharge routes cause the potential for polluted highway run-off and drainage to be directed towards new groundwater and surface water receptors with the new highways drainage system acting as a rapid pollutant pathway
- Contamination which has been encountered having been removed or remediated
- Improvement in surface water run-off quality as a result of additional treatment compared to existing conditions
- Reduction in soil erosion through improved drainage design and improvement in surface water run-off quality as a result of additional treatment compared to existing conditions.

Geodiversity

9.8.21 Appleby to Brough and Bowes Bypass schemes are situated partly within parts of the North Pennines AONB and the UNESCO Global Geopark. The permanent land take will encroach on the southern boundary of the AONB and UNESCO Global Geopark. The design has been engineered to avoid negative impacts to the UNESCO Global Geopark by considering alternative routes. The preferred alignment has further mitigated impacts by adjusting the alignment of the permanent works away from the designated site as much as practically possible.

Soils

9.8.22 During operation there will be no additional land lost. The loss of land has been considered in the construction phase. During the operational impacts to agricultural land and soils is largely attributed to road spray and accidental spillages. The banks of the River Eden and Tributaries SSSI and the River Eden SAC, located in Scheme 6 Temple Sowerby to Appleby, are immediately adjacent to the Project. The river and its tributaries could be affected by road salt spray. Salt can damage soil structure and so impact soil functions such as soil as a growing medium

and water storage, but mitigation such as better spreading techniques and roadside barriers should reduce salt drifting onto the soils.

9.8.23 The overall risks of salt damage in recent years have been greatly reduced by improved spreading techniques that reduce the amount of salt needed for efficient spreading. In high-speed situations such as main roads, salt spray is more likely to be a consideration than direct runoff. Considerations for the risks of salt damage include the traffic density and direction, the direction of the prevalent wind, the distance from the road, the incidence of cold weather, etc. The presence of roadside barriers can reduce the likelihood of salt damage and temporary barriers could be considered as a protective measure. Low growing species are more likely to be affected by spray whilst taller growing species are more likely to be affected through salt accumulating in soil, than by effects of salt on leaves on higher branches.

9.8.24 Alternatives to salt, such as urea have been proposed as more environmentally friendly. Clearly, the use of readily available nitrogen close to oligotrophic and nitrogen sensitive habitats, such as peat bog, are likely to be potentially more and not less deleterious. Therefore, a salt alternative would need to be carefully considered prior to use.

9.8.25 Hydrocarbons from exhaust fumes or tyre and brake residues which are deposited on the road can be mitigated by the construction of settlement ponds, which provide the opportunity to clean up the water before it reaches fields or watercourses. Barrier construction will help to reduce drift in areas of sensitive vegetation

9.8.26 Potential impacts associated with the operational effects from road pollution are assessed in Chapter 14: Road Drainage and the Water Environment, Chapter 6: Biodiversity, Chapter 5: Air quality and associated design, and embedded mitigation measures are provided.

9.9 Essential mitigation and enhancement measures

Construction

Design and embedded mitigation

9.9.1 Mitigation by design has been the primary consideration for the Project. Opportunities have been taken to avoid geological, geomorphological and soil receptors. The topic has been considered in design options developed to date, for example, the North Pennines are a designated geological site UNESCO Global Geopark. Whilst there is some encroachment into the UNESCO Global Geopark in order to provide local access facilities, the main A66 has been realigned southwards and the infrastructure within the boundary of the AONB and Geopark has been minimised as much as possible, to minimise impacts to the designated area. Excavations within the UNESCO Global Geopark shall be limited to the minimum required to deliver the Project as far as is reasonably practicable, to minimise disturbance and is secured through the EMP (Application Document 2.7).

9.9.2 Significant impacts to the ALC and BMV are anticipated Due to the surrounding environment and the nature of the Project comprising online improvements to an existing road , there is limited opportunity to avoid such impacts to soils.

9.9.3 An Environmental Management Plan (EMP) (Application Document 2.7), detailed in Chapter 2: The Project as been developed that contains measures to ensure compliance with relevant standards and legislation, included within this ES as Appendix 4.1 Environmental Management Plan. The EMP sets out the environmental mitigation requirements and also the Project level expectations on how the Project will be constructed, as proposed in the rest of this section. An Environmental Management Plan (EMP) (Application Document Number 2.7) has been developed that contains measures to ensure compliance with relevant standards and legislation. The EMP sets out the environmental mitigation requirements and also the Project level expectations on how the Project will be constructed, as proposed in the rest of this section.

9.9.4 A phase 1 preliminary Ground Investigation has been undertaken along the route, to identify baseline ground conditions within the Order Limits. The preliminary investigation provides a general indication of the ground conditions and is deemed sufficient to provide baseline information for this assessment and ES. Further ground investigation (Phase 2 GI) shall be undertaken prior to construction in order to inform the detailed design and is secured through the EMP (Application Document 2.7). Further ground investigation will enable further consideration of risks from possible historical contamination areas and those areas where elevated chemical concentrations were identified during the Phase 1 GI. Where risks are deemed to be significant, remediation options and strategies will be developed accordingly and agreed upon with the regulatory authorities.

9.9.5 Measures contained within the EMP are designed to limit the possibility for dispersal and accidental releases of potential contaminants, including fuel and spillages, soil derived dust and uncontrolled run-off to occur during construction. For example, the EMP sets out how the material is to be excavated, segregated and stockpiled to minimise the possibility of run-off, soil quality degradation and wind dispersal of dust.

9.9.6 Measures contained with the EMP include any remediation works applied to the existing ground or groundwater, and/or the removal of contaminated sources associated with the construction of the Project will break source-receptor linkages and will be a benefit to the environment. The remediation work will include a verification plan. A Verification report shall be prepared to detail the as built remedial works and identify any deviation from the verification plan.

9.9.7 The EMP also establishes procedures such as a contamination watching brief for dealing with unexpected soil or groundwater contamination that may be encountered.

9.9.8 The Principal Contractor(s) appointed to construct the Project will further develop the EMP as the detailed design evolves and a further iteration

of the EMP will be produced prior to commencement of construction to ensure compliance with the environmental requirements set out in the EMP.

9.9.9 Defra has worked with the Department of Trade and Industry to develop a *Construction Code of Practice for the Sustainable Use of Soils on Construction Sites* (DEFRA, 2009)[16]. The code of practice, which would be adopted for the construction of the Project, stipulates the following:

- Identification of soil resources at an early stage in the development process
- Improved planning of soil use
- A better level of soil management during project implementation, including the sustainable use of surplus soil
- Maintenance of soil quality and function both on and off site
- Avoidance of soil compaction and erosion (with a consequent reduction in flooding and water pollution)
- An improved knowledge and understanding of soil at all levels in the construction industry, including soil amelioration techniques.

9.9.10 The contractors shall comply with the *Construction Code of Practice for the Sustainable Use of Soils on Construction Sites*. Contractors are required to produce a Soil Resource Plan (SRP) as part of the Soil Management Plan (SMP). The Soil Survey and ground investigation findings will be used to inform the SRP.

9.9.11 The effects on soil resources will be mitigated by employing high standards of soil handling and management during construction, and by avoiding the creation of bare areas of exposed soil that would be vulnerable to erosion processes.

9.9.12 Topsoil stripped during the construction of the Project will be re-used as soon as is practicable and stored in such a way as to minimise structural damage from weathering, construction traffic movements, and multiple handling. This will also minimise the potential for leaching of nutrients from soils.

9.9.13 The re-use of excavated material will be governed by a Materials Management Plan (MMP) developed in accordance with the CL:AIRE *Code of Practice* (2014)[45]. The *Code of Practice* is a voluntary framework for excavated materials management and re-use. Complying with this framework results in a level of information being generated that is sufficient to demonstrate that excavated material has been re-used appropriately and is suitable for its intended use. A re-use criterion would be derived and detailed in the MMP alongside a verification plan. The MMP shall demonstrate that unsuitable material or waste has not been used in the development. The MMP will detail the procedures and measures that will be taken to classify, track, store, reuse and dispose of all excavated materials encountered during the construction works. Further details regarding the re-use of materials and waste are provided in Chapter 11: Materials and waste.

[45] Contaminated Land: Application in Real Environments (2014) Materials Management

9.9.14 Material that is required to be taken off site will be characterised in accordance with the *Environment Agency Technical Guidance WM3* (2015)[46] to determine the appropriate disposal facility, if unsuitable for treatment or re-use elsewhere.

9.9.15 In the event that imported topsoil is required the *BS 3882:2015 BSI* (*British Standards Institution) Standards Publication Specification for topsoil* (British Standards Institution, 2015)[47] shall be adopted and adhered to.

9.9.16 Potential impacts specific to construction workers during site preparation and construction will be mitigated by the following measures and through working in accordance with Construction Industry Research and Information Association (CIRIA) C741 4th Edition *Environmental Good Practice on Site* (2015)[48], included in the EMP (Application Document 2.7):

- Measures to minimise dust generation
- Provision of PPE, such as gloves, barrier cream, overalls etc. to minimise direct contact with soils
- Provision of adequate hygiene facilities and clean welfare facilities for all construction site workers
- Monitoring of confined spaces for possible ground gas accumulations, restricting access to confined spaces, i.e., to suitably trained personnel only, and use of specialist Personal Protective Equipment (PPE), where necessary
- Preparation and adoption of site and task specific health and safety plans as is required under Health and Safety legislation.

9.9.17 The EMP sets out the geology and soils-related construction phase monitoring requirements. These shall include any land to be restored as a result of construction works (as agreed with the landowner and National Highways). It is recommended that where feasible, no cuttings are excavated into the gypsum beds (Karst) of the Eden Shales Formation, and where gypsum is encountered, an additional site investigation is recommended with mitigation implemented to reduce the risk of dissolution as contained in ES Appendix 14.8: Desk Study Karst Risk Assessment (Application Document 3.4). Details of karst risk, identified features and potential mitigation measures can be found in ES Appendix 14.8: Desk Study Karst Risk Assessment (Application Document 3.4). Further details regarding groundwater mitiagtion measures are considered in Chapter 14: RDWE (Application Document 3.4).

9.9.18 Mitigation is secured via the REAC table within the EMP (Application Document 2.7)

[46] Environmental Agency (2015) Guidance on the classification and assessment of waste (1st Edition v1.2.GB) Technical Guidance WM3]
[47] British Standards Institution BSI (2015) Specification for topsoil BS 3882:2015
[48] Construction Industry Research and Information Association (2015) PUB C741 Environmental good practice on site guide. 4th edition

9.9.19 The primary measures to mitigate the impacts on soil resources would be set out in a SRP, as set out in the Soils Management Plan, Annex B9 of the EMP (Application Document 2.7) and secured by the DCO. The plan would confirm the different soil types (based on the soil surveys already undertaken); the most appropriate re-use for the different types of soils; and the proposed methods for handling, storing and replacing soils on-site.Compounds and storage areas should be sited to avoid the BMV soils where possible.

9.9.20 The aim of the SRP will be to re-use displaced soil resources on-site in the detailed design of open spaces and green infrastructure. The quality of soils retained on-site would be maintained by following good practice guidance on soils handling and storage, particularly to avoid compaction and degradation of soils.

9.9.21 With the adoption of appropriate mitigation for the handling and restoration of soils in the SRP, most soils will be able to continue their various ecosystem functions on the Site, principally as a medium for producing biomass; for storage and cycling of water and carbon; and for supporting habitats, biodiversity and landscape planting. Soils shall be restored to the quality prior to construction.

Enhancement mitigation measures

9.9.22 Where the construction of the Project cuts through the UNESCO Global Geopark there is little opportunity to provide the geological community safe access to view the geological exposures.

9.9.23 NH will engage with UNESCO to agree potential enhancement opportunities at the Geopark. If required an appropriate level of support shall be agreed, through engagement which is outside the scope of the Project.

Operation

9.9.24 Most impacts to geology and soils will occur during the construction stage. The operational impacts to geology and soils are limited to pollution, spraying and accidental spills. The design of the Project includes measures that will contain and control any releases of contaminants along the highway and its associated infrastructure such as drainage control. The drainage proposals for the Project are set out in Chapter 14: Road Drainage and the Water Environment) which includes measures to contain and control surface water run-off from the highway.

9.10 Assessment of likely significant effects

9.10.1 A full assessment has been carried out of all likely significant effects that could arise as a result of the Project on geology and soils during both construction and operation. In accordance with the Infrastructure Planning EIA Regulations, which require the identification of significant effects, and to ensure this ES is proportionate. The full assessment is presented in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

Likely effects not predicted to be significant following the assessment are presented in ES Appendix 9.1: Non-Significant Effects (Application Document 3.4).

9.10.2 This section describes only the likely geology and soils effects of the Project that are predicted to be significant.

9.10.3 In line with the assessment methodology set out in Section 9.4 the baseline study has identified geological, human health ground- and surface water and soil receptors within the Order Limits and study area. Receptor values within the Project study area range between negligible to very high value receptors.

9.10.4 An initial screening process has been undertaken on the potential land contamination sites identified in the baseline review (ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4)). The screening process seeks to identify areas of current or historical contaminative use that might pose contamination risks during construction and operation of the Project.

9.10.5 A ground investigation and ALC soil survey have been completed and used to inform the assessment.

9.10.6 The presence and classification of the agricultural soils and soils supporting ecological valuable sites within the study area have been determined through a review of published information. This has been further supplemented by a Project specific soil survey which has been carried out within the Order Limits.

9.10.7 A soil survey was undertaken to classify the soil grade within the Order Limits. The area of agricultural soils and BMV land that would be impacted, both temporarily and permanently, has been calculated on a scheme-by-scheme basis.

9.10.8 The potential impacts have been assessed for all schemes and the Project as a whole. With the implementation of standard best practice construction management measures, described in Section 9.9 above.

Construction

9.10.9 Table 9-39: Summary of significant effects (construction) outlines the conclusion of the assessment for the construction phase of the Project.

Geology and geodiversity

9.10.10 There are not expected to be any significant effects on geological receptors as a result of the construction phase of the Project. A UNESCO Global Geopark, of very high receptor value, is located with the Order Limits in the Appleby to Brough scheme. The scheme encroaches approximately 0.3km^2 into the southern boundary of the UNESCO Global Geopark, which is less that 0.1% of the overall Geopark area, which is approximately is 1,983km^2 in total . The magnitude of impact to the UNESCO Global Geopark is considered negligible, with very minor loss or detreimental alteration to the site. The overall integrity of the geological feature will not be affected. The

significance of the effects is a slight adverse effect, which is not considered significant.

Contamination

9.10.11 In determining whether there are any potential temporary effects on human health, groundwater, surface water, buildings or ecological receptors during the construction phase, the baseline risk has been compared against the predicted construction risk level. The assessment of risk is presented in section 1.2 of ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

9.10.12 Where there is no predicted change between the main baseline risk and the main construction risk, the temporary effect significance is deemed to be a neutral effect.

9.10.13 An increase in risk at the construction stage compared to baseline would result in an adverse effect and conversely, any improvement resulting from construction, for example where remediation is undertaken or a contaminant linkage is removed, would result in a beneficial effect. Whilst adoption of the measures in the EMP would make it unlikely that there would be adverse effects during construction for example, through the control of surface runoff and dust, it is considered that there may still be some temporary minor adverse effects during construction from ground disturbance or groundwater control, which will be managed through the EMP Minor temporary effects would not be considered significant.

9.10.14 A summary of the key considerations is provided as follows and details of the full assessment are presented in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4):

- The greatest risk to controlled waters (groundwater-principal aquifer) is associated with the historical and existing potentially contaminated sites situated above or near the Principal aquifer. The Principal aquifer is of high receptor value. The magnitude of impact at these locations has been assessed and ranges between no change and negligible effect due to the potential for ground disturbance during construction and contaminant mobilisation/migration with embedded and mitigation measures applied. The significance of the effects is neutral to slight adverse effect, which is not considered significant.
- During construction, human health receptors within the study area have the potential to be impacted by the construction works. Human health receptor values in the study area range from low to very high. The impact during construction, with embedded and mitigation measures applied for human health receptors within the study area, has been assessed. The magnitude of impact ranges between no change to neutral. The significance of the effects is neutral to slight adverse effect, which is not considered significant.

Soils

9.10.15 Where there is likely to be physical removal or permanent sealing of over 20ha of agricultural land this is assessed as a major magnitude of impact.

9.10.16 Where there is likely to be physical removal or permanent sealing of between 1ha and 20ha of agricultural land, or permanent loss/ reduction of one of or more soil functions this is assessed as a moderate magnitude of impact.

Temporary impacts

9.10.17 The construction of the Project will result in the temporary loss of approximately 112ha of BMV agricultural land Grade 2 and 3a. No ALC Grade 1 soil was identified in the Order Limits. Approximately 70 ha of Grade 2 soil and approximately 43 ha of Grade 3a will be temporarily impacted across the entire Project.

9.10.18 ALC Grade 2 soil is defined as of very high receptor value, ALC Grade 3a is defined as of high receptor value. The largest areas of BMV land to be temporarily impacted will be in the Penrith to Temple Sowerby and Temple Sowerby to Appleby scheme, with over 34ha and 2.8ha, respectivey being temporarily impacted. This is assessed as a major magnitude of impact. The significance of the effects is large to very large adverse effect, which is considered significant.

Permanent impacts

9.10.19 The construction of the Project will result in the permanent loss of approximately140 ha of BMV agricultural land. The loss will be of very good (ALC Grade 2) and good (ALC Grade 3a). Approximately 80 ha of Grade 2 soil and approximately 64 ha of Grade 3a will be permanently lost across the entire Project.

9.10.20 ALC Grade 2 soil is defined as of very high receptor value. ALC Grade 3a is defined as of high receptor value. The largest area of BMV land permanently lost will be in Temple Sowerby to Appleby, with over 70ha of the permanent land lake within this area. This is assessed as a major magnitude of impact. The significance of the effects is large to very large adverse effect, which is considered significant.

9.10.21 ALC Grade 3b has a medium receptor value. Approximately 130ha will be permanently lost across the Project. Permanent land take in Temple Sowerby to Appleby, Appleby to Brough and Stephen Bank to Carkin Moor all exceed 20ha. This is assessed as a major magnitude of impact. The significance of the effects is moderate or large adverse effect, which is considered significant.

9.10.22 ALC Grade 4 and 5 have a low receptor value. Approximately 30ha (major magnitude of impact) of Grade 4 soils will be lost Project wide. The significance of the effects for the Grade 4 soil is slight or moderate, which is considered significant.

9.10.23 3.5ha of Grade 5 soils will be lost (moderate magnitude of impact). The significance of the effects for the Grade 5 soil is slight, which is not considered significant.

9.10.24 Route wide there are soils of high to very high sensitivity present within the Order Limits. The impact to such soils is assessed as a major and moderate (adverse) magnitude of change. This therefore results in a Very large to large or very large adverse effect, which is considered significant.

Operation

9.10.25 Likely significant effects of the Project on receptors are not expected to arise during the operational phase. The impacts to geology and soils are likely to occur during the construction phase when excavation and earthworks take place.

9.10.26 The design of the Project includes measures that would contain and control any releases of contaminants along the highway and its associated infrastructure during the operational period, as set out in section 9.9 above. These include measures in the drainage design to prevent and minimise the risk of discharging pollutants into the Principal and Secondary A[49] aquifers via drainage pathways.

9.10.27 Impacts upon soils and agricultural land would occur during construction. Impacts on soil could occur as a result of the loss of agricultural land through permanent sealing or as a result of degradation to or loss of soils through processes such as compaction, contamination, mixing or erosion. Further impacts during operation do not typically arise.

Permanent effects

9.10.28 To determine whether there are any potential permanent effects, the baseline and operation CSM have been compared. The details of these comparisons are presented in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4).

9.10.29 The assessment has shown that whilst there are a number of minor beneficial impacts at the post construction stage, none of these would be regarded as significant in line with the methodology followed in ES Appendix 9.3: Geology and Soils Detailed Risk Assessment and Conceptual Site Models (Application Document 3.4). Minor beneficial effects relate to where the Project may remove a potential contaminant source either through physical removal of that source, ground or groundwater remediation or the introduction of a break in a contaminant linkage. There are minor beneficial effects for on and off-site users to groundwater contamination and ground gas (commercial/public open

[49] Principal Aquifer is layers of rock or drift deposits that have high intergranular and / or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and / or river base flow on a strategic scale
Secondary Aquifer is permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers

space) and on and off-site users (residential, and commercial/public open space) exposed to soil contamination for those CSMs for MoD land and light industrial sites respectively that are within the Order Limits as a result of remediation taking place should contamination be encountered. No significant permanent effects are identified. The non-significant effects are presented in ES Appendix 9.1: Non-Significant Effects (Application Document 3.4).

Summary

9.10.30 In summary, significant effects are anticipated on soils of ALC Grades 2, 3a (BMV land) Grade 3b and 4 as a result of large areas of ALC soils being permanently sealed or physically impaired as a result of the Project. The significant effects to soils will occur during construction phase. No further significant effects to geology and soils are anticipated during the construction and operational phase, post mitigation, as defined in T able 3.11 of *DMRB LA 109* and Table 3.8.1 of *DMRB LA 104 Environmental assessment and monitoring (DMRB LA 104)* (Highways England, 2020).

M6 Junction 40 to Kemplay Bank

Construction

9.10.31 A moderate magnitude of impact is predicted, for the topic of geology and soils, as a result of the construction phase of the Project. Moderate impacts are anticipated on ALC Grade 2 and Grade 3 soils (BMV land), with between 1- 20 ha of land permanently lost in this scheme. The significance of the effect on BMV is moderate or large to large or very large and is considered significant. Operation

9.10.32 There are no likely significant effects predicted on the topic of geology and soils as a result of the operational phase of the Project.

Penrith to Temple Sowerby

Construction

9.10.33 There are major and moderate magnitude of impacts predicted, for the topic of geology and soils, as a result of the construction phase of the Project. Major impacts are anticipated on ALC Grade 2 with over 20 ha of land permanently lost in this scheme and moderate impacts to Grade 3 soils with between 1- 20ha of land permanently sealed. The significance of the effect on BMV is moderate or large (Grade 3) and very large (Grade 2) and is considered significant.

Operation

9.10.34 There are no likely significant effects predicted on the topic of geology and soils as a result of the operational phase of the Project.

Temple Sowerby to Appleby

Construction

9.10.35 There are major and moderate magnitude of impacts predicted, for the topic of geology and soils, as a result of the construction phase of the Project. Major impacts are anticipated on ALC Grade 2 and Grade 3a with over 20 ha of land permanently lost in this scheme. Moderate impacts are anticipated to Grade 3b soils with between 1- 20ha of land permanently sealed. The significance of effect on BMV is very large (Grade 2), large or very large (Grade 3a); and to Grade 3b with moderate significance of effects. These are impacts are considered significant.

Operation

9.10.36 There are no likely significant effects predicted on the topic of geology and soils as a result of the operational phase of the Project.

Appleby to Brough

Construction

9.10.37 A major magnitude of impact is predicted, for the topic of geology and soils, as a result of the construction phase of the Project. Major impacts are anticipated on ALC Grade 3a with over 20 ha of land permanently lost in this scheme. Major impacts are anticipated to Grade 3b soils with approximately 50ha of land permanently sealed. The significance of effect on BMV is large or very large (Grade 3a) and moderate or large to Grade 3b soils. These are impacts are considered significant.

Operation

9.10.38 There are no likely significant effects predicted on the topic of geology and soils as a result of the operational phase of the Project.

Bowes Bypass

Construction

9.10.39 A moderate magnitude of impact is predicted, for the topic of geology and soils, as a result of the construction phase of the Project. Moderate impacts are anticipated to Grade 3b soils with between 1- 20ha of land permanently sealed. The significance of effect is moderate which is considered significant.

Operation

9.10.40 There are no likely significant effects predicted on the topic of geology and soils as a result of the operational phase of the Project.

Cross Lanes to Rokeby

Construction

9.10.41 A moderate magnitude of impact is predicted, for the topic of geology and soils, as a result of the construction phase of the Project. Moderate impacts are anticipated to Grade 3b soils with between 1- 20ha of land permanently sealed. Major impacts are anticipated to Grade 3b soils with between 1 and 20ha of land permanently sealed. The significance of effect is moderate, which is considered significant.

Operation

9.10.42 There are no likely significant effects predicted on the topic of geology and soils as a result of the operational phase of the Project.

Stephen Bank to Carkin Moor

Construction

9.10.43 A moderate magnitude of impact is predicted, for the topic of geology and soils, as a result of the construction phase of the Project. Moderate impacts are anticipated to Grade 3a soils (BMV land) with between 1-20ha of land permanently sealed. Major impacts are anticipated to Grade 3b soils with over 20ha of land permanently sealed. The significance of effect is moderate or large which is considered significant.

Operation

9.10.44 There are no likely significant effects predicted on the topic of geology and soils as a result of the operational phase of the Project.

A1(M) Junction 53 Scotch Corner

Construction

9.10.45 There are no likely significant effects predicted for the topic of geology and soils as a result of the construction phase of the Project.

Operation

9.10.46 There are no likely significant effects predicted on the topic of geology and soils as a result of the operational phase of the Project.

In-combination climate change

9.10.47 The in-combination climate change (ICCI) assessment has used a future climate baseline that is based on representative concentration pathway 8.5 (RCP 8.5) of the UK climate change 2018 projections (UKCP18). This future climate baseline is presented in Chapter 7: Climate.

9.10.48 Table 9-38: Geology and soils and In-combination climate change impacts below sets out the potential ICCI impacts to the project relevant to geology and soils.

Table 9-38: Geology and soils and In-combination climate change impacts

Effect impacted by climate change	Climate hazard(s)	Impact of climate hazard(s)	Impact on significance of the effect	Embedded mitigation or additional mitigation/ enhancement
Groundwater recharge	Number of hot days and heatwaves	Increased temperatures and number of hot days will potentially result in increased pressure on the existing water resources. This could result in a change of groundwater recharge rates.	Changes to the dissolution and transport of contaminants in groundwater and surface water. Increase pressure on ground well abstraction	Embedded mitigation: a cuttings assessment has been carried out to identify any areas of risk of excessive drawdown. All properties downgradient of the scheme are assumed to have private abstraction points to assess risk conservatively.
Flood risk	Increase in precipitation and increase in heavy rain days per year	Increased precipitation, especially in a short duration, has the potential to increase watercourse volume and flow rates. This, in combination with saturated ground conditions, gives an increased flood risk to excavations adjacent to the watercourses.	Ground instability such as side slope failure of the excavations and embankments. Erosion / undermining structures Washout failures of earthworks	Embedded existing mitigation: flood compensation has been integrated into the design, using climate uplift values.
Contamination mobility	Increase in precipitation and increase in heavy rain days per year.	Increase in contaminants mobility in surface water and groundwater.	Increased probability of contact from contaminants to groundwater, surface water, soils, geology, and human health.	Embedded existing mitigation: flood compensation has been integrated into the design, using climate uplift values.
	High temperatures and heat waves.	Increases in soil temperatures may Increase the rate of emission of volatile contaminants and gases in soils. An	Increased probability of contact from heavy metal contaminants to groundwater, surface water,	Heavy metals are less likely to be leached in drier conditions, leading to increased persistence

Effect impacted by climate change	Climate hazard(s)	Impact of climate hazard(s)	Impact on significance of the effect	Embedded mitigation or additional mitigation/ enhancement
		increase in temperatures can also decrease heavy metal mobility due to hotter conditions.	soils, geology, and human health.	in soils. Hardstanding/ engineered landscaping means there is unlikely to be any direct contact with underlying soils.
Fluctuating changes to groundwater levels.	Prolonged dry spells, increase in precipitation and increase in heavy rain days per year.	Increase in the mobility of waterborne contamination particles.	Increased probability of contact from contaminants to groundwater and surface water.	Embedded mitigation compensation has been integrated into the design, using climate uplift values.
Atmospheric pressure	Changes in atmospheric pressure can alter ground pressures and ground gas regimes	May increase rate emission of volatile contaminants and gases in soils.	Increased probability of contact from ground gases to groundwater, surface water, soils, geology, and human health.	Embedded mitigation: Phase 2 GI to measure ground gases over a variety of pressures to allow for a change of conditions, at targeted locations.
	Increase in wind speeds	Increase in the mobility of airborne contamination particles.	Increased probability of contact from ground gases to groundwater, surface water, soils, geology, and human health.	The consequence of this ICCI is very low and would be minimised as far as reasonably practicable using good construction practice measures.
Changes to moisture levels in soil	Decrease in summer precipitation, increase in dry spells and soil moisture deficit.	Dry exposed soils could lead to cracking in the soils which increased dust and airborne contaminated soils, reduction in soil depths and quality of the soil.	Increased probability of contact from ground gases to groundwater, surface water, soils, geology, and human health. Increased probability to impact on ALC soil quality. Cracking in dry soils can lead	Stockpiles will be suitably managed in accordance with relevant guidance from DEFRA, CIRIA and relevant British Standards.

Effect impacted by climate change	Climate hazard(s)	Impact of climate hazard(s)	Impact on significance of the effect	Embedded mitigation or additional mitigation/ enhancement
			to progressive failure of slopes	
		Differential settlement of ground caused by decreases in moisture content can be sufficient to damage property, roads, and infrastructure	Property receptors have increased exposure to ground gases and aggressive ground conditions.	Embedded mitigation compensation has been integrated into the design, using climate change predictions. The detailed design stage shall take ground conditions into consideration.

9.10.49 Impacts of climate change may affect geology and soils. UKCP18 projections suggest that changes to the climate by the 2020s (construction period) are unlikely to have a significant impact over this time scale. Over the longer term, (operational period) there is potential for impacts to the geology and soils as described above. Design and embedded mitigation have taken climate change into account. No additional mitigation is required.

Table 9-39: Summary of significant effects (construction)

Receptor	Attribute	Receptor sensitivity	Potential impact before essential mitigation	Essential mitigation/enhancement	Impact magnitude	Residual effect
Route wide						
Soil	ALC Grade 2	Very High	Permanent land take: Loss of very good quality agricultural land.	Production and implementation of a Soil Resource and Management Plan (SRMP), is secured in the EMP (Application Document 2.7)	Moderate	Large to very large
Soil	ALC Grade 2	Very High	Temporary land take: Potential for temporary or longer-term reduction in soil functions	Permanent land take cannot be mitigated but soil stripped may be a resource for landscaping use on or off site or for land restoration off site e.g., for agricultural, forestry, amenity use.	Moderate	Large to very large
Soil	ALC Grade 3a	High	Permanent land take: Loss of good quality agricultural land.		Moderate	Moderate or large
Soil	ALC Grade 3a	High	Temporary land take: Potential for temporary or longer-term reduction in soil functions		Moderate	Moderate or large
Soil	ALC Grade 3b	Medium	Permanent land take: Loss of mediumquality agricultural land.		Moderate	Moderate
Soil	ALC Grade 4	Low	Permanent land take: Loss of low quality agricultural land.		Major	Slight or moderate
M6 Junction 40 to Kemplay Bank						

Receptor	Attribute	Receptor sensitivity	Potential impact before essential mitigation	Essential mitigation/enhancement	Impact magnitude	Residual effect
Soils	ALC Grade 2	Very high	Temporary and permanent land take: Loss of very good quality agricultural land.	Temporary land take areas to avoid siting compounds or storage on BMV soil, where possible Permanent land take cannot be mitigated but soil stripped maybe a resource for landscaping use on or off site or for land restoration off site e.g., for agricultural, forestry, amenity use. Production and implementation of a Soil Resource and Management Plan (SRMP), secured in the EMP (Application Document 2.7)	Moderate	Large or very large
Soils	ALC Grade 3a	High	Temporary and Permanent land take: Loss of good quality agricultural land.		Moderate	Moderate or large
Penrith to Temple Sowerby						
Soils	ALC Grade 2	Very High	Temporary and permanent land take: Loss of very good quality agricultural land.	Temporary land take areas to avoid siting compounds or storage on BMV soil, where possible Permanent land take cannot be mitigated but soil stripped may be a resource for landscaping use on or off site or land restoration off site e.g., for agricultural, forestry, amenity use. Production and implementation of a Soil Resource and Management Plan (SRMP), secured in the EMP (Application Document 2.7).	Major	Very large
Soils	ALC Grade 3a	High	Permanent land take: Loss of very good quality agricultural land.		Moderate	Moderate or large

Receptor	Attribute	Receptor sensitivity	Potential impact before essential mitigation	Essential mitigation/enhancement	Impact magnitude	Residual effect
Temple Sowerby to Appleby						
Soils	ALC Grade 2	Very high	Temporary and permanent land take: Loss of very good quality agricultural land.	Temporary land take areas to avoid siting compounds or storage on BMV soil, where possible Permanent land take cannot be mitigated but soil stripped may be a resource for landscaping use on or off site or for land restoration off site e.g., for agricultural, forestry, amenity use. Production and implementation of a Soil Resource and Management Plan (SRMP) secured in the EMP (Application Document2.7).	Major	Very large
Soils	ALC Grade 3a	High	Temporary and permanent land take: Loss of good quality agricultural land.		Major	Large or very large
Soils	ALC Grade 3b	Medium	Temporary and permanent land take: Loss of good quality agricultural land.		Moderate	Moderate
Appleby to Brough						
Soils	ALC Grade 3a	High	Temporary and permanent land take: Loss of very good quality agricultural land.quality agricultural land.	Temporary land take areas to avoid siting compounds or storage on BMV soil, where possible Permanent land take cannot be mitigated but soil stripped may be a resource for landscaping use on or off site or for land restoration off site e.g., for agricultural, forestry, amenity use. Production and implementation of a Soil Resource and Management Plan (SRMP)	Major	Large or very large
Soils	ALC Grade 3b	Medium	Temporary and permanent land take: Loss of very good quality agricultural land.		Major	Moderate or large

Receptor	Attribute	Receptor sensitivity	Potential impact before essential mitigation	Essential mitigation/enhancement	Impact magnitude	Residual effect
				secured in the EMP (Application Document2.7).		
Bowes Bypass						
Soils	ALC Grade 3b	Medium	Permanent land take: Loss of medium quality agricultural land.	Temporary land take areas to avoid siting compounds or storage on BMV soil, where possible Permanent land take cannot be mitigated but soil stripped maybe a resource for landscaping use on or off site or land restoration off site e.g., for agricultural, forestry, amenity use, creation of species rich meadows. Production and implementation of a Soil Resource and Management Plan (SRMP) secured in the EMP (Application Document 2.7).	Moderate	Moderate
Cross Lanes to Rokeby						
Soils	ALC Grade 3b	Medium	Permanent land take: Loss of medium quality agricultural land.	Permanent land take cannot be mitigated but soil stripped maybe a resource for landscaping use on or off site or land restoration off site e.g., for agricultural, forestry, amenity use, creation of species rich meadows. Production and implementation of a Soil Resource and Management Plan (SRMP) secured in the EMP (Application Document 2.7).	Moderate	Moderate

Receptor	Attribute	Receptor sensitivity	Potential impact before essential mitigation	Essential mitigation/enhancement	Impact magnitude	Residual effect
Stephen Bank to Carkin Moor						
Soils	ALC Grade 3a	High	Temporary and permanent land take: Loss of good quality agricultural land.	Permanent land take cannot be mitigated but soil stripped maybe a resource for landscaping use on or off site or land restoration off site e.g., for agricultural, forestry, amenity use, creation of species rich meadows. Production and implementation of a Soil Resource and Management Plan (SRMP) secured in the EMP (Application Document 2.7).	Moderate	Moderate or large
Soils	ALC Grade 3b	Medium	Temporary and permanent land take: Loss of medium quality agricultural land.		Major	Moderate or large
A1(M) Junction 53 Scotch Corner						
N/A	N/A	N/A	N/A	N/A	N/A	N/A

9.11 Monitoring

Construction

9.11.1 Further targeted ground investigation will inform remediation strategies and the need for any further long-term monitoring. The phase 2 ground investigation and any remediation that may be required, should unexpected contamination be identified, will be designed in agreement with the relevant authorities as sercured in the EMP (Application Document 2.7).

9.11.2 Work shall be carried out in accordance with the EMP (Application Document 2.7) and so additional monitoring is considered unlikely.

Operation

9.11.3 Re-instated soils should be inspected periodically and monitored for signs of adverse conditions such as surface ponding, anaerobism and the failure of vegetation to establish which would all require amelioration. Details of inspections required would be included within the SRP, and any strategies required to treat applicable areas would be developed as necessary. The SRP is secured in the EMP (Application Document 2.7).

9.11.4 No further monitoring of the geology is proposed.

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